
MPI for Python

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Abstract

MPI for Python provides Python bindings for the *Message Passing Interface* (MPI) standard, allowing Python applications to exploit multiple processors on workstations, clusters and supercomputers.

This package builds on the MPI specification and provides an object oriented interface resembling the MPI-2 C++ bindings. It supports point-to-point (sends, receives) and collective (broadcasts, scatters, gathers) communication of any *pickleable* Python object, as well as efficient communication of Python objects exposing the Python buffer interface (e.g. NumPy arrays and builtin bytes/array/memoryview objects).

1 Introduction

Over the last years, high performance computing has become an affordable resource to many more researchers in the scientific community than ever before. The conjunction of quality open source software and commodity hardware strongly influenced the now widespread popularity of *Beowulf* class clusters and cluster of workstations.

Among many parallel computational models, message-passing has proven to be an effective one. This paradigm is specially suited for (but not limited to) distributed memory architectures and is used in today's most demanding scientific and engineering application related to modeling, simulation, design, and signal processing. However, portable message-passing parallel programming used to be a nightmare in the past because of the many incompatible options developers were faced to. Fortunately, this situation definitely changed after the MPI Forum released its standard specification.

High performance computing is traditionally associated with software development using compiled languages. However, in typical applications programs, only a small part of the code is time-critical enough to require the efficiency of compiled languages. The rest of the code is generally related to memory management, error handling, input/output, and user interaction, and those are usually the most error prone and time-consuming lines of code to write and debug in the whole development process. Interpreted high-level languages can be really advantageous for this kind of tasks.

For implementing general-purpose numerical computations, MATLAB¹ is the dominant interpreted programming language. In the open source side, Octave and Scilab are well known, freely distributed software packages providing compatibility with the MATLAB language. In this work, we present MPI for Python, a new package enabling applications to exploit multiple processors using standard MPI “look and feel” in Python scripts.

1.1 What is MPI?

MPI, [mpi-using] [mpi-ref] the *Message Passing Interface*, is a standardized and portable message-passing system designed to function on a wide variety of parallel computers. The standard defines the syntax and semantics of library routines and allows users to write portable programs in the main scientific programming languages (Fortran, C, or C++).

Since its release, the MPI specification [mpi-std1] [mpi-std2] has become the leading standard for message-passing libraries for parallel computers. Implementations are available from vendors of high-performance computers and from well known open source projects like MPICH [mpi-mpich] and Open MPI [mpi-openmpi].

1.2 What is Python?

Python is a modern, easy to learn, powerful programming language. It has efficient high-level data structures and a simple but effective approach to object-oriented programming with dynamic typing and dynamic binding. It supports modules and packages, which encourages program modularity and code reuse. Python’s elegant syntax, together with its interpreted nature, make it an ideal language for scripting and rapid application development in many areas on most platforms.

The Python interpreter and the extensive standard library are available in source or binary form without charge for all major platforms, and can be freely distributed. It is easily extended with new functions and data types implemented in C or C++. Python is also suitable as an extension language for customizable applications.

Python is an ideal candidate for writing the higher-level parts of large-scale scientific applications [Hinsen97] and driving simulations in parallel architectures [Beazley97] like clusters of PC’s or SMP’s. Python codes are quickly developed, easily maintained, and can achieve a high degree of integration with other libraries written in compiled languages.

1.3 Related Projects

As this work started and evolved, some ideas were borrowed from well known MPI and Python related open source projects from the Internet.

- OOMPI
 - It has no relation with Python, but is an excellent object oriented approach to MPI.
 - It is a C++ class library specification layered on top of the C bindings that encapsulates MPI into a functional class hierarchy.
 - It provides a flexible and intuitive interface by adding some abstractions, like *Ports* and *Messages*, which enrich and simplify the syntax.
- Pypar
 - Its interface is rather minimal. There is no support for communicators or process topologies.
 - It does not require the Python interpreter to be modified or recompiled, but does not permit interactive parallel runs.
 - General (*picklable*) Python objects of any type can be communicated. There is good support for numeric arrays, practically full MPI bandwidth can be achieved.
- pyMPI

¹ MATLAB is a registered trademark of The MathWorks, Inc.

- It rebuilds the Python interpreter providing a built-in module for message passing. It does permit interactive parallel runs, which are useful for learning and debugging.
- It provides an interface suitable for basic parallel programming. There is not full support for defining new communicators or process topologies.
- General (picklable) Python objects can be messaged between processors. There is native support for numeric arrays.
- **Scientific Python**
 - It provides a collection of Python modules that are useful for scientific computing.
 - There is an interface to MPI and BSP (*Bulk Synchronous Parallel programming*).
 - The interface is simple but incomplete and does not resemble the MPI specification. There is support for numeric arrays.

Additionally, we would like to mention some available tools for scientific computing and software development with Python.

- **NumPy** is a package that provides array manipulation and computational capabilities similar to those found in IDL, MATLAB, or Octave. Using NumPy, it is possible to write many efficient numerical data processing applications directly in Python without using any C, C++ or Fortran code.
- **SciPy** is an open source library of scientific tools for Python, gathering a variety of high level science and engineering modules together as a single package. It includes modules for graphics and plotting, optimization, integration, special functions, signal and image processing, genetic algorithms, ODE solvers, and others.
- **Cython** is a language that makes writing C extensions for the Python language as easy as Python itself. The Cython language is very close to the Python language, but Cython additionally supports calling C functions and declaring C types on variables and class attributes. This allows the compiler to generate very efficient C code from Cython code. This makes Cython the ideal language for wrapping for external C libraries, and for fast C modules that speed up the execution of Python code.
- **SWIG** is a software development tool that connects programs written in C and C++ with a variety of high-level programming languages like Perl, Tcl/Tk, Ruby and Python. Issuing header files to SWIG is the simplest approach to interfacing C/C++ libraries from a Python module.

2 Overview

MPI for Python provides an object oriented approach to message passing which grounds on the standard MPI-2 C++ bindings. The interface was designed with focus in translating MPI syntax and semantics of standard MPI-2 bindings for C++ to Python. Any user of the standard C/C++ MPI bindings should be able to use this module without need of learning a new interface.

2.1 Communicating Python Objects and Array Data

The Python standard library supports different mechanisms for data persistence. Many of them rely on disk storage, but *pickling* and *marshaling* can also work with memory buffers.

The `pickle` modules provide user-extensible facilities to serialize general Python objects using ASCII or binary formats. The `marshal` module provides facilities to serialize built-in Python objects using a binary format specific to Python, but independent of machine architecture issues.

MPI for Python can communicate any built-in or user-defined Python object taking advantage of the features provided by the `pickle` module. These facilities will be routinely used to build binary representations of objects to communicate (at sending processes), and restoring them back (at receiving processes).

Although simple and general, the serialization approach (i.e., *pickling* and *unpickling*) previously discussed imposes important overheads in memory as well as processor usage, especially in the scenario of objects with large memory footprints being communicated. Pickling general Python objects, ranging from primitive or container built-in types to user-defined classes, necessarily requires computer resources. Processing is also needed for dispatching the appropriate serialization method (that depends on the type of the object) and doing the actual packing. Additional memory is always needed, and if its total amount is not known *a priori*, many reallocations can occur. Indeed, in the case of large numeric arrays, this is certainly unacceptable and precludes communication of objects occupying half or more of the available memory resources.

MPI for Python supports direct communication of any object exporting the single-segment buffer interface. This interface is a standard Python mechanism provided by some types (e.g., strings and numeric arrays), allowing access in the C side to a contiguous memory buffer (i.e., address and length) containing the relevant data. This feature, in conjunction with the capability of constructing user-defined MPI datatypes describing complicated memory layouts, enables the implementation of many algorithms involving multidimensional numeric arrays (e.g., image processing, fast Fourier transforms, finite difference schemes on structured Cartesian grids) directly in Python, with negligible overhead, and almost as fast as compiled Fortran, C, or C++ codes.

2.2 Communicators

In *MPI for Python*, *Comm* is the base class of communicators. The *Intracomm* and *Intercomm* classes are subclasses of the *Comm* class. The *Comm.Is_inter* method (and *Comm.Is_intra*, provided for convenience but not part of the MPI specification) is defined for communicator objects and can be used to determine the particular communicator class.

The two predefined intracommunicator instances are available: *COMM_SELF* and *COMM_WORLD*. From them, new communicators can be created as needed.

The number of processes in a communicator and the calling process rank can be respectively obtained with methods *Comm.GetSize* and *Comm.GetRank*. The associated process group can be retrieved from a communicator by calling the *Comm.GetGroup* method, which returns an instance of the *Group* class. Set operations with *Group* objects like *Group.Union*, *Group.Intersection* and *Group.Difference* are fully supported, as well as the creation of new communicators from these groups using *Comm.Create* and *Intracomm.CreateGroup*.

New communicator instances can be obtained with the *Comm.Clone*, *Comm.Dup* and *Comm.Split* methods, as well methods *Intracomm.CreateIntercomm* and *Intercomm.Merge*.

Virtual topologies (*Cartcomm*, *Graphcomm* and *Distgraphcomm* classes, which are specializations of the *Intracomm* class) are fully supported. New instances can be obtained from intracommunicator instances with factory methods *Intracomm.CreateCart* and *Intracomm.CreateGraph*.

2.3 Point-to-Point Communications

Point to point communication is a fundamental capability of message passing systems. This mechanism enables the transmission of data between a pair of processes, one side sending, the other receiving.

MPI provides a set of *send* and *receive* functions allowing the communication of *typed* data with an associated *tag*. The type information enables the conversion of data representation from one architecture to another in the case of heterogeneous computing environments; additionally, it allows the representation of non-contiguous data layouts and user-defined datatypes, thus avoiding the overhead of (otherwise unavoidable) packing/unpacking operations. The tag information allows selectivity of messages at the receiving end.

Blocking Communications

MPI provides basic send and receive functions that are *blocking*. These functions block the caller until the data buffers involved in the communication can be safely reused by the application program.

In *MPI for Python*, the *Comm.Send*, *Comm.Recv* and *Comm.Sendrecv* methods of communicator objects provide support for blocking point-to-point communications within *Intracomm* and *Intercomm* instances. These methods

can communicate memory buffers. The variants `Comm.send`, `Comm.recv` and `Comm.sendrecv` can communicate general Python objects.

Nonblocking Communications

On many systems, performance can be significantly increased by overlapping communication and computation. This is particularly true on systems where communication can be executed autonomously by an intelligent, dedicated communication controller.

MPI provides *nonblocking* send and receive functions. They allow the possible overlap of communication and computation. Non-blocking communication always come in two parts: posting functions, which begin the requested operation; and test-for-completion functions, which allow to discover whether the requested operation has completed.

In *MPI for Python*, the `Comm.Isend` and `Comm.Irecv` methods initiate send and receive operations, respectively. These methods return a `Request` instance, uniquely identifying the started operation. Its completion can be managed using the `Request.Test`, `Request.Wait`, and `Request.Cancel` methods. The management of `Request` objects and associated memory buffers involved in communication requires a careful, rather low-level coordination. Users must ensure that objects exposing their memory buffers are not accessed at the Python level while they are involved in nonblocking message-passing operations.

Persistent Communications

Often a communication with the same argument list is repeatedly executed within an inner loop. In such cases, communication can be further optimized by using persistent communication, a particular case of nonblocking communication allowing the reduction of the overhead between processes and communication controllers. Furthermore, this kind of optimization can also alleviate the extra call overheads associated to interpreted, dynamic languages like Python.

In *MPI for Python*, the `Comm.Send_init` and `Comm.Recv_init` methods create persistent requests for a send and receive operation, respectively. These methods return an instance of the `Prequest` class, a subclass of the `Request` class. The actual communication can be effectively started using the `Prequest.Start` method, and its completion can be managed as previously described.

2.4 Collective Communications

Collective communications allow the transmittal of data between multiple processes of a group simultaneously. The syntax and semantics of collective functions is consistent with point-to-point communication. Collective functions communicate *typed* data, but messages are not paired with an associated *tag*; selectivity of messages is implied in the calling order.

The more commonly used collective communication operations are the following.

- Barrier synchronization across all group members.
- Global communication functions
 - Broadcast data from one member to all members of a group.
 - Gather data from all members to one member of a group.
 - Scatter data from one member to all members of a group.
- Global reduction operations such as sum, maximum, minimum, etc.

In *MPI for Python*, the `Comm.Bcast`, `Comm.Scatter`, `Comm.Gather`, `Comm.Allgather`, `Comm.Alltoall` methods provide support for collective communications of memory buffers. The lower-case variants `Comm.bcast`, `Comm.scatter`, `Comm.gather`, `Comm.allgather` and `Comm.alltoall` can communicate general Python objects. The vector variants (which can communicate different amounts of data to each process) `Comm.Scatterv`, `Comm.Gatherv`, `Comm.Allgatherv`, `Comm.Alltoallv` and `Comm.Alltoallw` are also supported, they can only communicate objects exposing memory buffers.

Global reduction operations on memory buffers are accessible through the *Comm.Reduce*, *Comm.Reduce_scatter*, *Comm.Allreduce*, *Intracomm.Scan* and *Intracomm.Exscan* methods. The lower-case variants *Comm.reduce*, *Comm.allreduce*, *Intracomm.scan* and *Intracomm.exscan* can communicate general Python objects; however, the actual required reduction computations are performed sequentially at some process. All the predefined (i.e., *SUM*, *PROD*, *MAX*, etc.) reduction operations can be applied.

2.5 Support for GPU-aware MPI

Several MPI implementations, including Open MPI and MVAPICH, support passing GPU pointers to MPI calls to avoid explicit data movement between host and device. On the Python side, support for handling GPU arrays have been implemented in many libraries related GPU computation such as *CuPy*, *Numba*, *PyTorch*, and *PyArrow*. To maximize interoperability across library boundaries, two kinds of zero-copy data exchange protocols have been defined and agreed upon: *DLPack* and *CUDA Array Interface (CAI)*.

MPI for Python provides an experimental support for GPU-aware MPI. This feature requires:

1. *mpi4py* is built against a GPU-aware MPI library.
2. The Python GPU arrays are compliant with either of the protocols.

See the *Tutorial* section for further information. We note that

- Whether or not a MPI call can work for GPU arrays depends on the underlying MPI implementation, not on *mpi4py*.
- This support is currently experimental and subject to change in the future.

2.6 Dynamic Process Management

In the context of the MPI-1 specification, a parallel application is static; that is, no processes can be added to or deleted from a running application after it has been started. Fortunately, this limitation was addressed in MPI-2. The new specification added a process management model providing a basic interface between an application and external resources and process managers.

This MPI-2 extension can be really useful, especially for sequential applications built on top of parallel modules, or parallel applications with a client/server model. The MPI-2 process model provides a mechanism to create new processes and establish communication between them and the existing MPI application. It also provides mechanisms to establish communication between two existing MPI applications, even when one did not *start* the other.

In *MPI for Python*, new independent process groups can be created by calling the *Intracomm.Spawn* method within an intracommunicator. This call returns a new intercommunicator (i.e., an *Intercomm* instance) at the parent process group. The child process group can retrieve the matching intercommunicator by calling the *Comm.Get_parent* class method. At each side, the new intercommunicator can be used to perform point to point and collective communications between the parent and child groups of processes.

Alternatively, disjoint groups of processes can establish communication using a client/server approach. Any server application must first call the *Open_port* function to open a *port* and the *Publish_name* function to publish a provided *service*, and next call the *Intracomm.Accept* method. Any client applications can first find a published *service* by calling the *Lookup_name* function, which returns the *port* where a server can be contacted; and next call the *Intracomm.Connect* method. Both *Intracomm.Accept* and *Intracomm.Connect* methods return an *Intercomm* instance. When connection between client/server processes is no longer needed, all of them must cooperatively call the *Comm.Disconnect* method. Additionally, server applications should release resources by calling the *Unpublish_name* and *Close_port* functions.

2.7 One-Sided Communications

One-sided communications (also called *Remote Memory Access*, *RMA*) supplements the traditional two-sided, send/receive based MPI communication model with a one-sided, put/get based interface. One-sided communication that can take advantage of the capabilities of highly specialized network hardware. Additionally, this extension lowers latency and software overhead in applications written using a shared-memory-like paradigm.

The MPI specification revolves around the use of objects called *windows*; they intuitively specify regions of a process's memory that have been made available for remote read and write operations. The published memory blocks can be accessed through three functions for put (remote send), get (remote write), and accumulate (remote update or reduction) data items. A much larger number of functions support different synchronization styles; the semantics of these synchronization operations are fairly complex.

In *MPI for Python*, one-sided operations are available by using instances of the `Win` class. New window objects are created by calling the `Win.Create` method at all processes within a communicator and specifying a memory buffer. When a window instance is no longer needed, the `Win.Free` method should be called.

The three one-sided MPI operations for remote write, read and reduction are available through calling the methods `Win.Put`, `Win.Get`, and `Win.Accumulate` respectively within a `Win` instance. These methods need an integer rank identifying the target process and an integer offset relative the base address of the remote memory block being accessed.

The one-sided operations read, write, and reduction are implicitly nonblocking, and must be synchronized by using two primary modes. Active target synchronization requires the origin process to call the `Win.Start` and `Win.Complete` methods at the origin process, and target process cooperates by calling the `Win.Post` and `Win.Wait` methods. There is also a collective variant provided by the `Win.Fence` method. Passive target synchronization is more lenient, only the origin process calls the `Win.Lock` and `Win.Unlock` methods. Locks are used to protect remote accesses to the locked remote window and to protect local load/store accesses to a locked local window.

2.8 Parallel Input/Output

The POSIX standard provides a model of a widely portable file system. However, the optimization needed for parallel input/output cannot be achieved with this generic interface. In order to ensure efficiency and scalability, the underlying parallel input/output system must provide a high-level interface supporting partitioning of file data among processes and a collective interface supporting complete transfers of global data structures between process memories and files. Additionally, further efficiencies can be gained via support for asynchronous input/output, strided accesses to data, and control over physical file layout on storage devices. This scenario motivated the inclusion in the MPI-2 standard of a custom interface in order to support more elaborated parallel input/output operations.

The MPI specification for parallel input/output revolves around the use objects called *files*. As defined by MPI, files are not just contiguous byte streams. Instead, they are regarded as ordered collections of *typed* data items. MPI supports sequential or random access to any integral set of these items. Furthermore, files are opened collectively by a group of processes.

The common patterns for accessing a shared file (broadcast, scatter, gather, reduction) is expressed by using user-defined datatypes. Compared to the communication patterns of point-to-point and collective communications, this approach has the advantage of added flexibility and expressiveness. Data access operations (read and write) are defined for different kinds of positioning (using explicit offsets, individual file pointers, and shared file pointers), coordination (non-collective and collective), and synchronism (blocking, nonblocking, and split collective with begin/end phases).

In *MPI for Python*, all MPI input/output operations are performed through instances of the `File` class. File handles are obtained by calling the `File.Open` method at all processes within a communicator and providing a file name and the intended access mode. After use, they must be closed by calling the `File.Close` method. Files even can be deleted by calling method `File.Delete`.

After creation, files are typically associated with a per-process *view*. The view defines the current set of data visible and accessible from an open file as an ordered set of elementary datatypes. This data layout can be set and queried with the `File.Set_view` and `File.Get_view` methods respectively.

Actual input/output operations are achieved by many methods combining read and write calls with different behavior regarding positioning, coordination, and synchronism. Summing up, *MPI for Python* provides the thirty (30) methods defined in MPI-2 for reading from or writing to files using explicit offsets or file pointers (individual or shared), in blocking or nonblocking and collective or noncollective versions.

2.9 Environmental Management

Initialization and Exit

Module functions *Init* or *Init_thread* and *Finalize* provide MPI initialization and finalization respectively. Module functions *Is_initialized* and *Is_finalized* provide the respective tests for initialization and finalization.

Note

`MPI_Init()` or `MPI_Init_thread()` is actually called when you import the *MPI* module from the *mpi4py* package, but only if MPI is not already initialized. In such case, calling *Init* or *Init_thread* from Python is expected to generate an MPI error, and in turn an exception will be raised.

Note

`MPI_Finalize()` is registered (by using Python C/API function `Py_AtExit()`) for being automatically called when Python processes exit, but only if *mpi4py* actually initialized MPI. Therefore, there is no need to call *Finalize* from Python to ensure MPI finalization.

Implementation Information

- The MPI version number can be retrieved from module function *Get_version*. It returns a two-integer tuple (version, subversion).
- The *Get_processor_name* function can be used to access the processor name.
- The values of predefined attributes attached to the world communicator can be obtained by calling the *Comm.Get_attr* method within the *COMM_WORLD* instance.

Timers

MPI timer functionalities are available through the *Wtime* and *Wtick* functions.

Error Handling

In order to facilitate handle sharing with other Python modules interfacing MPI-based parallel libraries, the predefined MPI error handlers *ERRORS_RETURN* and *ERRORS_ARE_FATAL* can be assigned to and retrieved from communicators using methods *Comm.Set_errhandler* and *Comm.Get_errhandler*, and similarly for windows and files. New custom error handlers can be created with *Comm.Create_errhandler*.

When the predefined error handler *ERRORS_RETURN* is set, errors returned from MPI calls within Python code will raise an instance of the exception class *Exception*, which is a subclass of the standard Python exception *RuntimeError*.

Note

After import, *mpi4py* overrides the default MPI rules governing inheritance of error handlers. The *ERRORS_RETURN* error handler is set in the predefined *COMM_SELF* and *COMM_WORLD* communicators, as well as any new *Comm*,

Win, or *File* instance created through `mpi4py`. If you ever pass such handles to C/C++/Fortran library code, it is recommended to set the `ERRORS_ARE_FATAL` error handler on them to ensure MPI errors do not pass silently.

Warning

Importing with `from mpi4py.MPI import *` will cause a name clashing with the standard Python `Exception` base class.

3 Tutorial

Warning

Under construction. Contributions very welcome!

Tip

Rolf Rabenseifner at HLRS developed a comprehensive MPI-3.1/4.0 course with slides and a large set of exercises including solutions. This material is [available online](#) for self-study. The slides and exercises show the C, Fortran, and Python (`mpi4py`) interfaces. For performance reasons, most Python exercises use NumPy arrays and communication routines involving buffer-like objects.

Tip

Victor Eijkhout at TACC authored the book *Parallel Programming for Science and Engineering*. This book is [available online](#) in PDF and HTML formats. The book covers parallel programming with MPI and OpenMP in C/C++ and Fortran, and MPI in Python using `mpi4py`.

MPI for Python supports convenient, *pickle*-based communication of generic Python object as well as fast, near C-speed, direct array data communication of buffer-provider objects (e.g., NumPy arrays).

- Communication of generic Python objects

You have to use methods with **all-lowercase** names, like `Comm.send`, `Comm.recv`, `Comm.bcast`, `Comm.scatter`, `Comm.gather`. An object to be sent is passed as a parameter to the communication call, and the received object is simply the return value.

The `Comm.isend` and `Comm.irecv` methods return `Request` instances; completion of these methods can be managed using the `Request.test` and `Request.wait` methods.

The `Comm.recv` and `Comm.irecv` methods may be passed a buffer object that can be repeatedly used to receive messages avoiding internal memory allocation. This buffer must be sufficiently large to accommodate the transmitted messages; hence, any buffer passed to `Comm.recv` or `Comm.irecv` must be at least as long as the *pickled* data transmitted to the receiver.

Collective calls like `Comm.scatter`, `Comm.gather`, `Comm.allgather`, `Comm.alltoall` expect a single value or a sequence of `Comm.size` elements at the root or all process. They return a single value, a list of `Comm.size` elements, or `None`.

Note

MPI for Python uses the **highest** protocol version available in the Python runtime (see the `HIGHEST_PROTOCOL` constant in the `pickle` module). The default protocol can be changed at import time by setting the `MPI4PY_PICKLE_PROTOCOL` environment variable, or at runtime by assigning a different value to the `PROTOCOL` attribute of the `pickle` object within the `MPI` module.

- Communication of buffer-like objects

You have to use method names starting with an **upper-case** letter, like `Comm.Send`, `Comm.Recv`, `Comm.Bcast`, `Comm.Scatter`, `Comm.Gather`.

In general, buffer arguments to these calls must be explicitly specified by using a 2/3-list/tuple like `[data, MPI.DOUBLE]`, or `[data, count, MPI.DOUBLE]` (the former one uses the byte-size of `data` and the extent of the MPI datatype to define `count`).

For vector collectives communication operations like `Comm.Scatterv` and `Comm.Gatherv`, buffer arguments are specified as `[data, count, displ, datatype]`, where `count` and `displ` are sequences of integral values.

Automatic MPI datatype discovery for NumPy/GPU arrays and PEP-3118 buffers is supported, but limited to basic C types (all C/C99-native signed/unsigned integral types and single/double precision real/complex floating types) and availability of matching datatypes in the underlying MPI implementation. In this case, the buffer-provider object can be passed directly as a buffer argument, the count and MPI datatype will be inferred.

If `mpi4py` is built against a GPU-aware MPI implementation, GPU arrays can be passed to upper-case methods as long as they have either the `__dlpack__` and `__dlpack_device__` methods or the `__cuda_array_interface__` attribute that are compliant with the respective standard specifications. Moreover, only C-contiguous or Fortran-contiguous GPU arrays are supported. It is important to note that GPU buffers must be fully ready before any MPI routines operate on them to avoid race conditions. This can be ensured by using the synchronization API of your array library. `mpi4py` does not have access to any GPU-specific functionality and thus cannot perform this operation automatically for users.

3.1 Running Python scripts with MPI

Most MPI programs can be run with the command `mpiexec`. In practice, running Python programs looks like:

```
$ mpiexec -n 4 python script.py
```

to run the program with 4 processors.

3.2 Point-to-Point Communication

- Python objects (`pickle` under the hood):

```
from mpi4py import MPI

comm = MPI.COMM_WORLD
rank = comm.Get_rank()

if rank == 0:
    data = {'a': 7, 'b': 3.14}
    comm.send(data, dest=1, tag=11)
elif rank == 1:
    data = comm.recv(source=0, tag=11)
```

- Python objects with non-blocking communication:

```

from mpi4py import MPI

comm = MPI.COMM_WORLD
rank = comm.Get_rank()

if rank == 0:
    data = {'a': 7, 'b': 3.14}
    req = comm.isend(data, dest=1, tag=11)
    req.wait()
elif rank == 1:
    req = comm.irecv(source=0, tag=11)
    data = req.wait()

```

- NumPy arrays (the fast way!):

```

from mpi4py import MPI
import numpy

comm = MPI.COMM_WORLD
rank = comm.Get_rank()

# passing MPI datatypes explicitly
if rank == 0:
    data = numpy.arange(1000, dtype='i')
    comm.Send([data, MPI.INT], dest=1, tag=77)
elif rank == 1:
    data = numpy.empty(1000, dtype='i')
    comm.Recv([data, MPI.INT], source=0, tag=77)

# automatic MPI datatype discovery
if rank == 0:
    data = numpy.arange(100, dtype=numpy.float64)
    comm.Send(data, dest=1, tag=13)
elif rank == 1:
    data = numpy.empty(100, dtype=numpy.float64)
    comm.Recv(data, source=0, tag=13)

```

3.3 Collective Communication

- Broadcasting a Python dictionary:

```

from mpi4py import MPI

comm = MPI.COMM_WORLD
rank = comm.Get_rank()

if rank == 0:
    data = {'key1' : [7, 2.72, 2+3j],
            'key2' : ('abc', 'xyz')}
else:
    data = None
data = comm.bcast(data, root=0)

```

- Scattering Python objects:

```

from mpi4py import MPI

comm = MPI.COMM_WORLD
size = comm.Get_size()
rank = comm.Get_rank()

if rank == 0:
    data = [(i+1)**2 for i in range(size)]
else:
    data = None
data = comm.scatter(data, root=0)
assert data == (rank+1)**2

```

- Gathering Python objects:

```

from mpi4py import MPI

comm = MPI.COMM_WORLD
size = comm.Get_size()
rank = comm.Get_rank()

data = (rank+1)**2
data = comm.gather(data, root=0)
if rank == 0:
    for i in range(size):
        assert data[i] == (i+1)**2
else:
    assert data is None

```

- Broadcasting a NumPy array:

```

from mpi4py import MPI
import numpy as np

comm = MPI.COMM_WORLD
rank = comm.Get_rank()

if rank == 0:
    data = np.arange(100, dtype='i')
else:
    data = np.empty(100, dtype='i')
comm.Bcast(data, root=0)
for i in range(100):
    assert data[i] == i

```

- Scattering NumPy arrays:

```

from mpi4py import MPI
import numpy as np

comm = MPI.COMM_WORLD
size = comm.Get_size()
rank = comm.Get_rank()

```

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```
sendbuf = None
if rank == 0:
    sendbuf = np.empty([size, 100], dtype='i')
    sendbuf.T[:, :] = range(size)
recvbuf = np.empty(100, dtype='i')
comm.Scatter(sendbuf, recvbuf, root=0)
assert np.allclose(recvbuf, rank)
```

- Gathering NumPy arrays:

```
from mpi4py import MPI
import numpy as np

comm = MPI.COMM_WORLD
size = comm.Get_size()
rank = comm.Get_rank()

sendbuf = np.zeros(100, dtype='i') + rank
recvbuf = None
if rank == 0:
    recvbuf = np.empty([size, 100], dtype='i')
comm.Gather(sendbuf, recvbuf, root=0)
if rank == 0:
    for i in range(size):
        assert np.allclose(recvbuf[i, :], i)
```

- Parallel matrix-vector product:

```
from mpi4py import MPI
import numpy

def matvec(comm, A, x):
    m = A.shape[0] # local rows
    p = comm.Get_size()
    xg = numpy.zeros(m*p, dtype='d')
    comm.Allgather([x, MPI.DOUBLE],
                  [xg, MPI.DOUBLE])
    y = numpy.dot(A, xg)
    return y
```

3.4 Input/Output (MPI-IO)

- Collective I/O with NumPy arrays:

```
from mpi4py import MPI
import numpy as np

amode = MPI.MODE_WRONLY | MPI.MODE_CREATE
comm = MPI.COMM_WORLD
fh = MPI.File.Open(comm, "./datafile.contig", amode)
```

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```
buffer = np.empty(10, dtype=np.int)
buffer[:] = comm.Get_rank()

offset = comm.Get_rank()*buffer.nbytes
fh.Write_at_all(offset, buffer)

fh.Close()
```

- Non-contiguous Collective I/O with NumPy arrays and datatypes:

```
from mpi4py import MPI
import numpy as np

comm = MPI.COMM_WORLD
rank = comm.Get_rank()
size = comm.Get_size()

amode = MPI.MODE_WRONLY | MPI.MODE_CREATE
fh = MPI.File.Open(comm, "./datafile.noncontig", amode)

item_count = 10

buffer = np.empty(item_count, dtype='i')
buffer[:] = rank

filetype = MPI.INT.Create_vector(item_count, 1, size)
filetype.Commit()

displacement = MPI.INT.Get_size()*rank
fh.Set_view(displacement, filetype=filetype)

fh.Write_all(buffer)
filetype.Free()
fh.Close()
```

3.5 Dynamic Process Management

- Compute Pi - Master (or parent, or client) side:

```
#!/usr/bin/env python
from mpi4py import MPI
import numpy
import sys

comm = MPI.COMM_SELF.Spawn(sys.executable,
                           args=['cpi.py'],
                           maxprocs=5)

N = numpy.array(100, 'i')
comm.Bcast([N, MPI.INT], root=MPI.ROOT)
PI = numpy.array(0.0, 'd')
comm.Reduce(None, [PI, MPI.DOUBLE],
```

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```
        op=MPI.SUM, root=MPI.ROOT)
print(PI)

comm.Disconnect()
```

- Compute Pi - Worker (or child, or server) side:

```
#!/usr/bin/env python
from mpi4py import MPI
import numpy

comm = MPI.Comm.Get_parent()
size = comm.Get_size()
rank = comm.Get_rank()

N = numpy.array(0, dtype='i')
comm.Bcast([N, MPI.INT], root=0)
h = 1.0 / N; s = 0.0
for i in range(rank, N, size):
    x = h * (i + 0.5)
    s += 4.0 / (1.0 + x**2)
PI = numpy.array(s * h, dtype='d')
comm.Reduce([PI, MPI.DOUBLE], None,
            op=MPI.SUM, root=0)

comm.Disconnect()
```

3.6 GPU-aware MPI + Python GPU arrays

- Reduce-to-all CuPy arrays:

```
from mpi4py import MPI
import cupy as cp

comm = MPI.COMM_WORLD
size = comm.Get_size()
rank = comm.Get_rank()

sendbuf = cp.arange(10, dtype='i')
recvbuf = cp.empty_like(sendbuf)
cp.cuda.get_current_stream().synchronize()
comm.Allreduce(sendbuf, recvbuf)

assert cp.allclose(recvbuf, sendbuf*size)
```

3.7 One-Sided Communication (RMA)

- Read from (write to) the entire RMA window:

```
import numpy as np
from mpi4py import MPI
from mpi4py.util import dtlib
```

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```
comm = MPI.COMM_WORLD
rank = comm.Get_rank()

datatype = MPI.FLOAT
np_dtype = dtlib.to_numpy_dtype(datatype)
itemsize = datatype.Get_size()

N = 10
win_size = N * itemsize if rank == 0 else 0
win = MPI.Win.Allocate(win_size, comm=comm)

buf = np.empty(N, dtype=np_dtype)
if rank == 0:
    buf.fill(42)
    win.Lock(rank=0)
    win.Put(buf, target_rank=0)
    win.Unlock(rank=0)
    comm.Barrier()
else:
    comm.Barrier()
    win.Lock(rank=0)
    win.Get(buf, target_rank=0)
    win.Unlock(rank=0)
    assert np.all(buf == 42)
```

- Accessing a part of the RMA window using the target argument, which is defined as (offset, count, datatype):

```
import numpy as np
from mpi4py import MPI
from mpi4py.util import dtlib

comm = MPI.COMM_WORLD
rank = comm.Get_rank()

datatype = MPI.FLOAT
np_dtype = dtlib.to_numpy_dtype(datatype)
itemsize = datatype.Get_size()

N = comm.Get_size() + 1
win_size = N * itemsize if rank == 0 else 0
win = MPI.Win.Allocate(
    size=win_size,
    disp_unit=itemsize,
    comm=comm,
)
if rank == 0:
    mem = np.frombuffer(win, dtype=np_dtype)
    mem[:] = np.arange(len(mem), dtype=np_dtype)
comm.Barrier()
```

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```
buf = np.zeros(3, dtype=np_dtype)
target = (rank, 2, datatype)
win.Lock(rank=0)
win.Get(buf, target_rank=0, target=target)
win.Unlock(rank=0)
assert np.all(buf == [rank, rank+1, 0])
```

3.8 Wrapping with SWIG

- C source:

```
/* file: helloworld.c */
void sayhello(MPI_Comm comm)
{
    int size, rank;
    MPI_Comm_size(comm, &size);
    MPI_Comm_rank(comm, &rank);
    printf("Hello, World! "
           "I am process %d of %d.\n",
           rank, size);
}
```

- SWIG interface file:

```
// file: helloworld.i
%module helloworld
%{
#include <mpi.h>
#include "helloworld.c"
}%

#include mpi4py/mpi4py.i
%mpi4py_typemap(Comm, MPI_Comm);
void sayhello(MPI_Comm comm);
```

- Try it in the Python prompt:

```
>>> from mpi4py import MPI
>>> import helloworld
>>> helloworld.sayhello(MPI.COMM_WORLD)
Hello, World! I am process 0 of 1.
```

3.9 Wrapping with F2Py

- Fortran 90 source:

```
! file: helloworld.f90
subroutine sayhello(comm)
    use mpi
    implicit none
    integer :: comm, rank, size, ierr
    call MPI_Comm_size(comm, size, ierr)
```

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```
call MPI_Comm_rank(comm, rank, ierr)
print *, 'Hello, World! I am process ',rank,' of ',size,'.'
end subroutine sayhello
```

- Compiling example using f2py

```
$ f2py -c --f90exec=mpif90 helloworld.f90 -m helloworld
```

- Try it in the Python prompt:

```
>>> from mpi4py import MPI
>>> import helloworld
>>> fcomm = MPI.COMM_WORLD.py2f()
>>> helloworld.sayhello(fcomm)
Hello, World! I am process 0 of 1.
```

4 mpi4py

The **MPI for Python** package.

The *Message Passing Interface* (MPI) is a standardized and portable message-passing system designed to function on a wide variety of parallel computers. The MPI standard defines the syntax and semantics of library routines and allows users to write portable programs in the main scientific programming languages (Fortran, C, or C++). Since its release, the MPI specification has become the leading standard for message-passing libraries for parallel computers.

MPI for Python provides MPI bindings for the Python programming language, allowing any Python program to exploit multiple processors. This package build on the MPI specification and provides an object oriented interface which closely follows MPI-2 C++ bindings.

4.1 Runtime configuration options

`mpi4py.rc`

This object has attributes exposing runtime configuration options that become effective at import time of the *MPI* module.

Attributes Summary

<code>initialize</code>	Automatic MPI initialization at import
<code>threads</code>	Request initialization with thread support
<code>thread_level</code>	Level of thread support to request
<code>finalize</code>	Automatic MPI finalization at exit
<code>fast_reduce</code>	Use tree-based reductions for objects
<code>recv_mprobe</code>	Use matched probes to receive objects
<code>irecv_bufsz</code>	Default buffer size in bytes for <code>irecv()</code>
<code>errors</code>	Error handling policy

Attributes Documentation

`mpi4py.rc.initialize`

Automatic MPI initialization at import.

Type
bool

Default
True

➔ See also

MPI4PY_RC_INITIALIZE

`mpi4py.rc.threads`

Request initialization with thread support.

Type
bool

Default
True

➔ See also

MPI4PY_RC_THREADS

`mpi4py.rc.thread_level`

Level of thread support to request.

Type
str

Default
"multiple"

Choices
"multiple", "serialized", "funneled", "single"

➔ See also

MPI4PY_RC_THREAD_LEVEL

`mpi4py.rc.finalize`

Automatic MPI finalization at exit.

If set to `None`, the value of `mpi4py.rc.initialize` is used.

Type
None or bool

Default
None

➔ See also

MPI4PY_RC_FINALIZE

`mpi4py.rc.fast_reduce`

Use tree-based reductions for objects.

Type
`bool`

Default
`True`

 **See also**

[`MPI4PY_RC_FAST_REDUCE`](#)

`mpi4py.rc.recv_mprobe`

Use matched probes to receive objects.

Type
`bool`

Default
`True`

 **See also**

[`MPI4PY_RC_RECV_MPROBE`](#)

`mpi4py.rc.irecv_bufsz`

Default buffer size in bytes for `irecv()`.

Type
`int`

Default
`32768`

 **See also**

[`MPI4PY_RC_IRecv_BUFSZ`](#)

Added in version 4.0.0.

`mpi4py.rc.errors`

Error handling policy.

Type
`str`

Default
`"exception"`

Choices
`"exception", "default", "abort", "fatal"`

 **See also**

[MPI4PY_RC_ERRORS](#)

Example

MPI for Python features automatic initialization and finalization of the MPI execution environment. By using the `mpi4py.rc` object, MPI initialization and finalization can be handled programmatically:

```
import mpi4py
mpi4py.rc.initialize = False # do not initialize MPI automatically
mpi4py.rc.finalize = False  # do not finalize MPI automatically

from mpi4py import MPI # import the 'MPI' module

MPI.Init()           # manual initialization of the MPI environment
...                 # your finest code here ...
MPI.Finalize()       # manual finalization of the MPI environment
```

4.2 Environment variables

The following environment variables override the corresponding attributes of the `mpi4py.rc` and `MPI.pickle` objects at import time of the `MPI` module.

 **Note**

For variables of boolean type, accepted values are `0` and `1` (interpreted as `False` and `True`, respectively), and strings specifying a [YAML boolean value](#) (case-insensitive).

MPI4PY_RC_INITIALIZE

Type
bool

Default
True

Whether to automatically initialize MPI at import time of the `mpi4py.MPI` module.

 **See also**

`mpi4py.rc.initialize`

Added in version 4.0.0.

MPI4PY_RC_FINALIZE

Type
None | bool

Default
None

Choices

None, True, False

Whether to automatically finalize MPI at exit time of the Python process.

 **See also**

[mpi4py.rc.finalize](#)

Added in version 4.0.0.

MPI4PY_RC_THREADS**Type**

bool

Default

True

Whether to initialize MPI with thread support.

 **See also**

[mpi4py.rc.threads](#)

Added in version 3.1.0.

MPI4PY_RC_THREAD_LEVEL**Default**

"multiple"

Choices

"single", "funneled", "serialized", "multiple"

The level of required thread support.

 **See also**

[mpi4py.rc.thread_level](#)

Added in version 3.1.0.

MPI4PY_RC_FAST_REDUCE**Type**

bool

Default

True

Whether to use tree-based reductions for objects.

 **See also**

[mpi4py.rc.fast_reduce](#)

Added in version 3.1.0.

MPI4PY_RC_RECV_MPROBE

Type
`bool`

Default
`True`

Whether to use matched probes to receive objects.

 **See also**

`mpi4py.rc.recv_mprobe`

MPI4PY_RC_IRecv_BUFSZ

Type
`int`

Default
`32768`

Default buffer size in bytes for `irecv()`.

 **See also**

`mpi4py.rc.irecv_bufsz`

Added in version 4.0.0.

MPI4PY_RC_ERRORS

Default
`"exception"`

Choices
`"exception", "default", "abort", "fatal"`

Controls default MPI error handling policy.

 **See also**

`mpi4py.rc.errors`

Added in version 3.1.0.

MPI4PY_PICKLE_PROTOCOL

Type
`int`

Default
`pickle.HIGHEST_PROTOCOL`

Controls the default pickle protocol to use when communicating Python objects.

➔ See also

`PROTOCOL` attribute of the `MPI.pickle` object within the `MPI` module.

Added in version 3.1.0.

`MPI4PY_PICKLE_THRESHOLD`

Type

`int`

Default

262144

Controls the default buffer size threshold for switching from in-band to out-of-band buffer handling when using pickle protocol version 5 or higher.

➔ See also

`THRESHOLD` attribute of the `MPI.pickle` object within the `MPI` module.

Added in version 3.1.2.

4.3 Miscellaneous functions

`mpi4py.profile`(*name*, * (*Keyword-only parameters separator (PEP 3102)*), *path=None*)

Support for the MPI profiling interface.

Parameters

- **name** (`str`) – Name of the profiler library to load.
- **path** (`sequence of str, optional`) – Additional paths to search for the profiler.

Return type

`None`

`mpi4py.get_include`()

Return the directory in the package that contains header files.

Extension modules that need to compile against `mpi4py` should use this function to locate the appropriate include directory. Using Python distutils (or perhaps NumPy distutils):

```
import mpi4py
Extension('extension_name', ...
         include_dirs=[..., mpi4py.get_include()])
```

Return type

`str`

`mpi4py.get_config`()

Return a dictionary with information about MPI.

Changed in version 4.0.0: By default, this function returns an empty dictionary. However, downstream packagers and distributors may alter such behavior. To that end, MPI information must be provided under an `mpi` section within a UTF-8 encoded INI-style configuration file `mpi.cfg` located at the top-level package directory. The configuration file is read and parsed using the `configparser` module.

Return type
dict[str, str]

5 mpi4py.MPI

5.1 Classes

Ancillary

<i>Datatype</i>	Datatype object.
<i>Status</i>	Status object.
<i>Request</i>	Request handler.
<i>Prequest</i>	Persistent request handler.
<i>Grequest</i>	Generalized request handler.
<i>Op</i>	Reduction operation.
<i>Group</i>	Group of processes.
<i>Info</i>	Info object.
<i>Session</i>	Session context.

Communication

<i>Comm</i>	Communication context.
<i>Intracomm</i>	Intracommunicator.
<i>Topocomm</i>	Topology intracommunicator.
<i>Cartcomm</i>	Cartesian topology intracommunicator.
<i>Graphcomm</i>	General graph topology intracommunicator.
<i>Distgraphcomm</i>	Distributed graph topology intracommunicator.
<i>Intercomm</i>	Intercommunicator.
<i>Message</i>	Matched message.

One-sided operations

<i>Win</i>	Remote memory access context.
------------	-------------------------------

Input/Output

<i>File</i>	File I/O context.
-------------	-------------------

Error handling

<i>Errhandler</i>	Error handler.
<i>Exception</i>	Exception class.

Auxiliary

<i>Pickle</i>	Pickle/unpickle Python objects.
<i>buffer</i>	Buffer.

5.2 Functions

Version inquiry

<i>Get_version()</i>	Obtain the version number of the MPI standard.
<i>Get_library_version()</i>	Obtain the version string of the MPI library.

Initialization and finalization

<i>Init()</i>	Initialize the MPI execution environment.
<i>Init_thread</i> ([required])	Initialize the MPI execution environment.
<i>Finalize()</i>	Terminate the MPI execution environment.
<i>Is_initialized()</i>	Indicate whether <i>Init</i> has been called.
<i>Is_finalized()</i>	Indicate whether <i>Finalize</i> has completed.
<i>Query_thread()</i>	Return the level of thread support provided by the MPI library.
<i>Is_thread_main()</i>	Indicate whether this thread called <i>Init</i> or <i>Init_thread</i> .

Memory allocation

<i>Alloc_mem</i> (size[, info])	Allocate memory for message passing and remote memory access.
<i>Free_mem</i> (mem)	Free memory allocated with <i>Alloc_mem</i> .

Address manipulation

<i>Get_address</i> (location)	Get the address of a location in memory.
<i>Aint_add</i> (base, disp)	Return the sum of base address and displacement.
<i>Aint_diff</i> (addr1, addr2)	Return the difference between absolute addresses.

Timer

<i>Wtick()</i>	Return the resolution of <i>Wtime</i> .
<i>Wtime()</i>	Return an elapsed time on the calling processor.

Error handling

<i>Get_error_class</i> (errorcode)	Convert an <i>error code</i> into an <i>error class</i> .
<i>Get_error_string</i> (errorcode)	Return the <i>error string</i> for a given <i>error class</i> or <i>error code</i> .
<i>Add_error_class</i> ()	Add an <i>error class</i> to the known error classes.
<i>Add_error_code</i> (errorclass)	Add an <i>error code</i> to an <i>error class</i> .
<i>Add_error_string</i> (errorcode, string)	Associate an <i>error string</i> with an <i>error class</i> or <i>error code</i> .
<i>Remove_error_class</i> (errorclass)	Remove an <i>error class</i> from the known error classes.
<i>Remove_error_code</i> (errorcode)	Remove an <i>error code</i> from the known error codes.
<i>Remove_error_string</i> (errorcode)	Remove <i>error string</i> association from <i>error class</i> or <i>error code</i> .

Dynamic process management

<i>Open_port</i> ([info])	Return an address used to connect group of processes.
<i>Close_port</i> (port_name)	Close a port.
<i>Publish_name</i> (service_name, port_name[, info])	Publish a service name.
<i>Unpublish_name</i> (service_name, port_name[, info])	Unpublish a service name.
<i>Lookup_name</i> (service_name[, info])	Lookup a port name given a service name.

Miscellanea

<i>Attach_buffer</i> (buf)	Attach a user-provided buffer for sending in buffered mode.
<i>Detach_buffer</i> ()	Remove an existing attached buffer.
<i>Flush_buffer</i> ()	Block until all buffered messages have been transmitted.
<i>Iflush_buffer</i> ()	Nonblocking flush for buffered messages.
<i>Compute_dims</i> (nnodes, dims)	Return a balanced distribution of processes per coordinate direction.
<i>Get_processor_name</i> ()	Obtain the name of the calling processor.
<i>Register_datarep</i> (datarep, read_fn, write_fn, ...)	Register user-defined data representations.
<i>Pcontrol</i> (level)	Control profiling.

Utilities

<i>get_vendor</i> ()	Information about the underlying MPI implementation.
----------------------	------------------------------------------------------

5.3 Attributes

<i>UNDEFINED</i>	Constant UNDEFINED of type <i>int</i>
<i>ANY_SOURCE</i>	Constant ANY_SOURCE of type <i>int</i>
<i>ANY_TAG</i>	Constant ANY_TAG of type <i>int</i>
<i>PROC_NULL</i>	Constant PROC_NULL of type <i>int</i>

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Table 16 – continued from previous page

<i>ROOT</i>	Constant <i>ROOT</i> of type <i>int</i>
<i>BOTTOM</i>	Object <i>BOTTOM</i> of type <i>BottomType</i>
<i>IN_PLACE</i>	Object <i>IN_PLACE</i> of type <i>InPlaceType</i>
<i>BUFFER_AUTOMATIC</i>	Object <i>BUFFER_AUTOMATIC</i> of type <i>BufferAutomaticType</i>
<i>KEYVAL_INVALID</i>	Constant <i>KEYVAL_INVALID</i> of type <i>int</i>
<i>TAG_UB</i>	Constant <i>TAG_UB</i> of type <i>int</i>
<i>IO</i>	Constant <i>IO</i> of type <i>int</i>
<i>WTIME_IS_GLOBAL</i>	Constant <i>WTIME_IS_GLOBAL</i> of type <i>int</i>
<i>UNIVERSE_SIZE</i>	Constant <i>UNIVERSE_SIZE</i> of type <i>int</i>
<i>APPNUM</i>	Constant <i>APPNUM</i> of type <i>int</i>
<i>LASTUSEDPCODE</i>	Constant <i>LASTUSEDPCODE</i> of type <i>int</i>
<i>WIN_BASE</i>	Constant <i>WIN_BASE</i> of type <i>int</i>
<i>WIN_SIZE</i>	Constant <i>WIN_SIZE</i> of type <i>int</i>
<i>WIN_DISP_UNIT</i>	Constant <i>WIN_DISP_UNIT</i> of type <i>int</i>
<i>WIN_CREATE_FLAVOR</i>	Constant <i>WIN_CREATE_FLAVOR</i> of type <i>int</i>
<i>WIN_FLAVOR</i>	Constant <i>WIN_FLAVOR</i> of type <i>int</i>
<i>WIN_MODEL</i>	Constant <i>WIN_MODEL</i> of type <i>int</i>
<i>SUCCESS</i>	Constant <i>SUCCESS</i> of type <i>int</i>
<i>ERR_LASTCODE</i>	Constant <i>ERR_LASTCODE</i> of type <i>int</i>
<i>ERR_COMM</i>	Constant <i>ERR_COMM</i> of type <i>int</i>
<i>ERR_GROUP</i>	Constant <i>ERR_GROUP</i> of type <i>int</i>
<i>ERR_TYPE</i>	Constant <i>ERR_TYPE</i> of type <i>int</i>
<i>ERR_REQUEST</i>	Constant <i>ERR_REQUEST</i> of type <i>int</i>
<i>ERR_OP</i>	Constant <i>ERR_OP</i> of type <i>int</i>
<i>ERR_ERRHANDLER</i>	Constant <i>ERR_ERRHANDLER</i> of type <i>int</i>
<i>ERR_BUFFER</i>	Constant <i>ERR_BUFFER</i> of type <i>int</i>
<i>ERR_COUNT</i>	Constant <i>ERR_COUNT</i> of type <i>int</i>
<i>ERR_TAG</i>	Constant <i>ERR_TAG</i> of type <i>int</i>
<i>ERR_RANK</i>	Constant <i>ERR_RANK</i> of type <i>int</i>
<i>ERR_ROOT</i>	Constant <i>ERR_ROOT</i> of type <i>int</i>
<i>ERR_TRUNCATE</i>	Constant <i>ERR_TRUNCATE</i> of type <i>int</i>
<i>ERR_IN_STATUS</i>	Constant <i>ERR_IN_STATUS</i> of type <i>int</i>
<i>ERR_PENDING</i>	Constant <i>ERR_PENDING</i> of type <i>int</i>
<i>ERR_TOPOLOGY</i>	Constant <i>ERR_TOPOLOGY</i> of type <i>int</i>
<i>ERR_DIMS</i>	Constant <i>ERR_DIMS</i> of type <i>int</i>
<i>ERR_ARG</i>	Constant <i>ERR_ARG</i> of type <i>int</i>
<i>ERR_OTHER</i>	Constant <i>ERR_OTHER</i> of type <i>int</i>
<i>ERR_UNKNOWN</i>	Constant <i>ERR_UNKNOWN</i> of type <i>int</i>
<i>ERR_INTERN</i>	Constant <i>ERR_INTERN</i> of type <i>int</i>
<i>ERR_INFO</i>	Constant <i>ERR_INFO</i> of type <i>int</i>
<i>ERR_FILE</i>	Constant <i>ERR_FILE</i> of type <i>int</i>
<i>ERR_WIN</i>	Constant <i>ERR_WIN</i> of type <i>int</i>
<i>ERR_KEYVAL</i>	Constant <i>ERR_KEYVAL</i> of type <i>int</i>
<i>ERR_INFO_KEY</i>	Constant <i>ERR_INFO_KEY</i> of type <i>int</i>
<i>ERR_INFO_VALUE</i>	Constant <i>ERR_INFO_VALUE</i> of type <i>int</i>
<i>ERR_INFO_NOKEY</i>	Constant <i>ERR_INFO_NOKEY</i> of type <i>int</i>
<i>ERR_ACCESS</i>	Constant <i>ERR_ACCESS</i> of type <i>int</i>
<i>ERR_AMODE</i>	Constant <i>ERR_AMODE</i> of type <i>int</i>
<i>ERR_BAD_FILE</i>	Constant <i>ERR_BAD_FILE</i> of type <i>int</i>
<i>ERR_FILE_EXISTS</i>	Constant <i>ERR_FILE_EXISTS</i> of type <i>int</i>
<i>ERR_FILE_IN_USE</i>	Constant <i>ERR_FILE_IN_USE</i> of type <i>int</i>

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Table 16 – continued from previous page

<i>ERR_NO_SPACE</i>	Constant <i>ERR_NO_SPACE</i> of type <i>int</i>
<i>ERR_NO_SUCH_FILE</i>	Constant <i>ERR_NO_SUCH_FILE</i> of type <i>int</i>
<i>ERR_IO</i>	Constant <i>ERR_IO</i> of type <i>int</i>
<i>ERR_READ_ONLY</i>	Constant <i>ERR_READ_ONLY</i> of type <i>int</i>
<i>ERR_CONVERSION</i>	Constant <i>ERR_CONVERSION</i> of type <i>int</i>
<i>ERR_DUP_DATAREP</i>	Constant <i>ERR_DUP_DATAREP</i> of type <i>int</i>
<i>ERR_UNSUPPORTED_DATAREP</i>	Constant <i>ERR_UNSUPPORTED_DATAREP</i> of type <i>int</i>
<i>ERR_UNSUPPORTED_OPERATION</i>	Constant <i>ERR_UNSUPPORTED_OPERATION</i> of type <i>int</i>
<i>ERR_NAME</i>	Constant <i>ERR_NAME</i> of type <i>int</i>
<i>ERR_NO_MEM</i>	Constant <i>ERR_NO_MEM</i> of type <i>int</i>
<i>ERR_NOT_SAME</i>	Constant <i>ERR_NOT_SAME</i> of type <i>int</i>
<i>ERR_PORT</i>	Constant <i>ERR_PORT</i> of type <i>int</i>
<i>ERR_QUOTA</i>	Constant <i>ERR_QUOTA</i> of type <i>int</i>
<i>ERR_SERVICE</i>	Constant <i>ERR_SERVICE</i> of type <i>int</i>
<i>ERR_SPAWN</i>	Constant <i>ERR_SPAWN</i> of type <i>int</i>
<i>ERR_BASE</i>	Constant <i>ERR_BASE</i> of type <i>int</i>
<i>ERR_SIZE</i>	Constant <i>ERR_SIZE</i> of type <i>int</i>
<i>ERR_DISP</i>	Constant <i>ERR_DISP</i> of type <i>int</i>
<i>ERR_ASSERT</i>	Constant <i>ERR_ASSERT</i> of type <i>int</i>
<i>ERR_LOCKTYPE</i>	Constant <i>ERR_LOCKTYPE</i> of type <i>int</i>
<i>ERR_RMA_CONFLICT</i>	Constant <i>ERR_RMA_CONFLICT</i> of type <i>int</i>
<i>ERR_RMA_SYNC</i>	Constant <i>ERR_RMA_SYNC</i> of type <i>int</i>
<i>ERR_RMA_RANGE</i>	Constant <i>ERR_RMA_RANGE</i> of type <i>int</i>
<i>ERR_RMA_ATTACH</i>	Constant <i>ERR_RMA_ATTACH</i> of type <i>int</i>
<i>ERR_RMA_SHARED</i>	Constant <i>ERR_RMA_SHARED</i> of type <i>int</i>
<i>ERR_RMA_FLAVOR</i>	Constant <i>ERR_RMA_FLAVOR</i> of type <i>int</i>
<i>ORDER_C</i>	Constant <i>ORDER_C</i> of type <i>int</i>
<i>ORDER_F</i>	Constant <i>ORDER_F</i> of type <i>int</i>
<i>ORDER_FORTRAN</i>	Constant <i>ORDER_FORTRAN</i> of type <i>int</i>
<i>TYPECLASS_INTEGER</i>	Constant <i>TYPECLASS_INTEGER</i> of type <i>int</i>
<i>TYPECLASS_REAL</i>	Constant <i>TYPECLASS_REAL</i> of type <i>int</i>
<i>TYPECLASS_COMPLEX</i>	Constant <i>TYPECLASS_COMPLEX</i> of type <i>int</i>
<i>DISTRIBUTE_NONE</i>	Constant <i>DISTRIBUTE_NONE</i> of type <i>int</i>
<i>DISTRIBUTE_BLOCK</i>	Constant <i>DISTRIBUTE_BLOCK</i> of type <i>int</i>
<i>DISTRIBUTE_CYCLIC</i>	Constant <i>DISTRIBUTE_CYCLIC</i> of type <i>int</i>
<i>DISTRIBUTE_DFLT_DARG</i>	Constant <i>DISTRIBUTE_DFLT_DARG</i> of type <i>int</i>
<i>COMBINER_NAMED</i>	Constant <i>COMBINER_NAMED</i> of type <i>int</i>
<i>COMBINER_DUP</i>	Constant <i>COMBINER_DUP</i> of type <i>int</i>
<i>COMBINER_CONTIGUOUS</i>	Constant <i>COMBINER_CONTIGUOUS</i> of type <i>int</i>
<i>COMBINER_VECTOR</i>	Constant <i>COMBINER_VECTOR</i> of type <i>int</i>
<i>COMBINER_HVECTOR</i>	Constant <i>COMBINER_HVECTOR</i> of type <i>int</i>
<i>COMBINER_INDEXED</i>	Constant <i>COMBINER_INDEXED</i> of type <i>int</i>
<i>COMBINER_HINDEXED</i>	Constant <i>COMBINER_HINDEXED</i> of type <i>int</i>
<i>COMBINER_INDEXED_BLOCK</i>	Constant <i>COMBINER_INDEXED_BLOCK</i> of type <i>int</i>
<i>COMBINER_HINDEXED_BLOCK</i>	Constant <i>COMBINER_HINDEXED_BLOCK</i> of type <i>int</i>
<i>COMBINER_STRUCT</i>	Constant <i>COMBINER_STRUCT</i> of type <i>int</i>
<i>COMBINER_SUBARRAY</i>	Constant <i>COMBINER_SUBARRAY</i> of type <i>int</i>
<i>COMBINER_DARRAY</i>	Constant <i>COMBINER_DARRAY</i> of type <i>int</i>
<i>COMBINER_RESIZED</i>	Constant <i>COMBINER_RESIZED</i> of type <i>int</i>
<i>COMBINER_VALUE_INDEX</i>	Constant <i>COMBINER_VALUE_INDEX</i> of type <i>int</i>
<i>COMBINER_F90_REAL</i>	Constant <i>COMBINER_F90_REAL</i> of type <i>int</i>
<i>COMBINER_F90_COMPLEX</i>	Constant <i>COMBINER_F90_COMPLEX</i> of type <i>int</i>

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Table 16 – continued from previous page

<i>COMBINER_F90_INTEGER</i>	Constant <i>COMBINER_F90_INTEGER</i> of type <i>int</i>
<i>IDENT</i>	Constant <i>IDENT</i> of type <i>int</i>
<i>CONGRUENT</i>	Constant <i>CONGRUENT</i> of type <i>int</i>
<i>SIMILAR</i>	Constant <i>SIMILAR</i> of type <i>int</i>
<i>UNEQUAL</i>	Constant <i>UNEQUAL</i> of type <i>int</i>
<i>CART</i>	Constant <i>CART</i> of type <i>int</i>
<i>GRAPH</i>	Constant <i>GRAPH</i> of type <i>int</i>
<i>DIST_GRAPH</i>	Constant <i>DIST_GRAPH</i> of type <i>int</i>
<i>UNWEIGHTED</i>	Constant <i>UNWEIGHTED</i> of type <i>int</i>
<i>WEIGHTS_EMPTY</i>	Constant <i>WEIGHTS_EMPTY</i> of type <i>int</i>
<i>COMM_TYPE_SHARED</i>	Constant <i>COMM_TYPE_SHARED</i> of type <i>int</i>
<i>BSEND_OVERHEAD</i>	Constant <i>BSEND_OVERHEAD</i> of type <i>int</i>
<i>WIN_FLAVOR_CREATE</i>	Constant <i>WIN_FLAVOR_CREATE</i> of type <i>int</i>
<i>WIN_FLAVOR_ALLOCATE</i>	Constant <i>WIN_FLAVOR_ALLOCATE</i> of type <i>int</i>
<i>WIN_FLAVOR_DYNAMIC</i>	Constant <i>WIN_FLAVOR_DYNAMIC</i> of type <i>int</i>
<i>WIN_FLAVOR_SHARED</i>	Constant <i>WIN_FLAVOR_SHARED</i> of type <i>int</i>
<i>WIN_SEPARATE</i>	Constant <i>WIN_SEPARATE</i> of type <i>int</i>
<i>WIN_UNIFIED</i>	Constant <i>WIN_UNIFIED</i> of type <i>int</i>
<i>MODE_NOCHECK</i>	Constant <i>MODE_NOCHECK</i> of type <i>int</i>
<i>MODE_NOSTORE</i>	Constant <i>MODE_NOSTORE</i> of type <i>int</i>
<i>MODE_NOPUT</i>	Constant <i>MODE_NOPUT</i> of type <i>int</i>
<i>MODE_NOPRECEDE</i>	Constant <i>MODE_NOPRECEDE</i> of type <i>int</i>
<i>MODE_NOSUCCEED</i>	Constant <i>MODE_NOSUCCEED</i> of type <i>int</i>
<i>LOCK_EXCLUSIVE</i>	Constant <i>LOCK_EXCLUSIVE</i> of type <i>int</i>
<i>LOCK_SHARED</i>	Constant <i>LOCK_SHARED</i> of type <i>int</i>
<i>MODE_RDONLY</i>	Constant <i>MODE_RDONLY</i> of type <i>int</i>
<i>MODE_WRONLY</i>	Constant <i>MODE_WRONLY</i> of type <i>int</i>
<i>MODE_RDWR</i>	Constant <i>MODE_RDWR</i> of type <i>int</i>
<i>MODE_CREATE</i>	Constant <i>MODE_CREATE</i> of type <i>int</i>
<i>MODE_EXCL</i>	Constant <i>MODE_EXCL</i> of type <i>int</i>
<i>MODE_DELETE_ON_CLOSE</i>	Constant <i>MODE_DELETE_ON_CLOSE</i> of type <i>int</i>
<i>MODE_UNIQUE_OPEN</i>	Constant <i>MODE_UNIQUE_OPEN</i> of type <i>int</i>
<i>MODE_SEQUENTIAL</i>	Constant <i>MODE_SEQUENTIAL</i> of type <i>int</i>
<i>MODE_APPEND</i>	Constant <i>MODE_APPEND</i> of type <i>int</i>
<i>SEEK_SET</i>	Constant <i>SEEK_SET</i> of type <i>int</i>
<i>SEEK_CUR</i>	Constant <i>SEEK_CUR</i> of type <i>int</i>
<i>SEEK_END</i>	Constant <i>SEEK_END</i> of type <i>int</i>
<i>DISPLACEMENT_CURRENT</i>	Constant <i>DISPLACEMENT_CURRENT</i> of type <i>int</i>
<i>DISP_CUR</i>	Constant <i>DISP_CUR</i> of type <i>int</i>
<i>THREAD_SINGLE</i>	Constant <i>THREAD_SINGLE</i> of type <i>int</i>
<i>THREAD_FUNNELED</i>	Constant <i>THREAD_FUNNELED</i> of type <i>int</i>
<i>THREAD_SERIALIZED</i>	Constant <i>THREAD_SERIALIZED</i> of type <i>int</i>
<i>THREAD_MULTIPLE</i>	Constant <i>THREAD_MULTIPLE</i> of type <i>int</i>
<i>VERSION</i>	Constant <i>VERSION</i> of type <i>int</i>
<i>SUBVERSION</i>	Constant <i>SUBVERSION</i> of type <i>int</i>
<i>MAX_PROCESSOR_NAME</i>	Constant <i>MAX_PROCESSOR_NAME</i> of type <i>int</i>
<i>MAX_ERROR_STRING</i>	Constant <i>MAX_ERROR_STRING</i> of type <i>int</i>
<i>MAX_PORT_NAME</i>	Constant <i>MAX_PORT_NAME</i> of type <i>int</i>
<i>MAX_INFO_KEY</i>	Constant <i>MAX_INFO_KEY</i> of type <i>int</i>
<i>MAX_INFO_VAL</i>	Constant <i>MAX_INFO_VAL</i> of type <i>int</i>
<i>MAX_OBJECT_NAME</i>	Constant <i>MAX_OBJECT_NAME</i> of type <i>int</i>
<i>MAX_DATAREP_STRING</i>	Constant <i>MAX_DATAREP_STRING</i> of type <i>int</i>

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<code>MAX_LIBRARY_VERSION_STRING</code>	Constant <code>MAX_LIBRARY_VERSION_STRING</code> of type <code>int</code>
<code>DATATYPE_NULL</code>	Object <code>DATATYPE_NULL</code> of type <i>Datatype</i>
<code>PACKED</code>	Object <code>PACKED</code> of type <i>Datatype</i>
<code>BYTE</code>	Object <code>BYTE</code> of type <i>Datatype</i>
<code>AINT</code>	Object <code>AINT</code> of type <i>Datatype</i>
<code>OFFSET</code>	Object <code>OFFSET</code> of type <i>Datatype</i>
<code>COUNT</code>	Object <code>COUNT</code> of type <i>Datatype</i>
<code>CHAR</code>	Object <code>CHAR</code> of type <i>Datatype</i>
<code>WCHAR</code>	Object <code>WCHAR</code> of type <i>Datatype</i>
<code>SIGNED_CHAR</code>	Object <code>SIGNED_CHAR</code> of type <i>Datatype</i>
<code>SHORT</code>	Object <code>SHORT</code> of type <i>Datatype</i>
<code>INT</code>	Object <code>INT</code> of type <i>Datatype</i>
<code>LONG</code>	Object <code>LONG</code> of type <i>Datatype</i>
<code>LONG_LONG</code>	Object <code>LONG_LONG</code> of type <i>Datatype</i>
<code>UNSIGNED_CHAR</code>	Object <code>UNSIGNED_CHAR</code> of type <i>Datatype</i>
<code>UNSIGNED_SHORT</code>	Object <code>UNSIGNED_SHORT</code> of type <i>Datatype</i>
<code>UNSIGNED</code>	Object <code>UNSIGNED</code> of type <i>Datatype</i>
<code>UNSIGNED_LONG</code>	Object <code>UNSIGNED_LONG</code> of type <i>Datatype</i>
<code>UNSIGNED_LONG_LONG</code>	Object <code>UNSIGNED_LONG_LONG</code> of type <i>Datatype</i>
<code>FLOAT</code>	Object <code>FLOAT</code> of type <i>Datatype</i>
<code>DOUBLE</code>	Object <code>DOUBLE</code> of type <i>Datatype</i>
<code>LONG_DOUBLE</code>	Object <code>LONG_DOUBLE</code> of type <i>Datatype</i>
<code>C_BOOL</code>	Object <code>C_BOOL</code> of type <i>Datatype</i>
<code>INT8_T</code>	Object <code>INT8_T</code> of type <i>Datatype</i>
<code>INT16_T</code>	Object <code>INT16_T</code> of type <i>Datatype</i>
<code>INT32_T</code>	Object <code>INT32_T</code> of type <i>Datatype</i>
<code>INT64_T</code>	Object <code>INT64_T</code> of type <i>Datatype</i>
<code>UINT8_T</code>	Object <code>UINT8_T</code> of type <i>Datatype</i>
<code>UINT16_T</code>	Object <code>UINT16_T</code> of type <i>Datatype</i>
<code>UINT32_T</code>	Object <code>UINT32_T</code> of type <i>Datatype</i>
<code>UINT64_T</code>	Object <code>UINT64_T</code> of type <i>Datatype</i>
<code>C_COMPLEX</code>	Object <code>C_COMPLEX</code> of type <i>Datatype</i>
<code>C_FLOAT_COMPLEX</code>	Object <code>C_FLOAT_COMPLEX</code> of type <i>Datatype</i>
<code>C_DOUBLE_COMPLEX</code>	Object <code>C_DOUBLE_COMPLEX</code> of type <i>Datatype</i>
<code>C_LONG_DOUBLE_COMPLEX</code>	Object <code>C_LONG_DOUBLE_COMPLEX</code> of type <i>Datatype</i>
<code>CXX_BOOL</code>	Object <code>CXX_BOOL</code> of type <i>Datatype</i>
<code>CXX_FLOAT_COMPLEX</code>	Object <code>CXX_FLOAT_COMPLEX</code> of type <i>Datatype</i>
<code>CXX_DOUBLE_COMPLEX</code>	Object <code>CXX_DOUBLE_COMPLEX</code> of type <i>Datatype</i>
<code>CXX_LONG_DOUBLE_COMPLEX</code>	Object <code>CXX_LONG_DOUBLE_COMPLEX</code> of type <i>Datatype</i>
<code>SHORT_INT</code>	Object <code>SHORT_INT</code> of type <i>Datatype</i>
<code>INT_INT</code>	Object <code>INT_INT</code> of type <i>Datatype</i>
<code>TWOINT</code>	Object <code>TWOINT</code> of type <i>Datatype</i>
<code>LONG_INT</code>	Object <code>LONG_INT</code> of type <i>Datatype</i>
<code>FLOAT_INT</code>	Object <code>FLOAT_INT</code> of type <i>Datatype</i>
<code>DOUBLE_INT</code>	Object <code>DOUBLE_INT</code> of type <i>Datatype</i>
<code>LONG_DOUBLE_INT</code>	Object <code>LONG_DOUBLE_INT</code> of type <i>Datatype</i>
<code>CHARACTER</code>	Object <code>CHARACTER</code> of type <i>Datatype</i>
<code>LOGICAL</code>	Object <code>LOGICAL</code> of type <i>Datatype</i>
<code>INTEGER</code>	Object <code>INTEGER</code> of type <i>Datatype</i>
<code>REAL</code>	Object <code>REAL</code> of type <i>Datatype</i>
<code>DOUBLE_PRECISION</code>	Object <code>DOUBLE_PRECISION</code> of type <i>Datatype</i>
<code>COMPLEX</code>	Object <code>COMPLEX</code> of type <i>Datatype</i>

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<i>DOUBLE_COMPLEX</i>	Object <i>DOUBLE_COMPLEX</i> of type <i>Datatype</i>
<i>LOGICAL1</i>	Object <i>LOGICAL1</i> of type <i>Datatype</i>
<i>LOGICAL2</i>	Object <i>LOGICAL2</i> of type <i>Datatype</i>
<i>LOGICAL4</i>	Object <i>LOGICAL4</i> of type <i>Datatype</i>
<i>LOGICAL8</i>	Object <i>LOGICAL8</i> of type <i>Datatype</i>
<i>INTEGER1</i>	Object <i>INTEGER1</i> of type <i>Datatype</i>
<i>INTEGER2</i>	Object <i>INTEGER2</i> of type <i>Datatype</i>
<i>INTEGER4</i>	Object <i>INTEGER4</i> of type <i>Datatype</i>
<i>INTEGER8</i>	Object <i>INTEGER8</i> of type <i>Datatype</i>
<i>INTEGER16</i>	Object <i>INTEGER16</i> of type <i>Datatype</i>
<i>REAL2</i>	Object <i>REAL2</i> of type <i>Datatype</i>
<i>REAL4</i>	Object <i>REAL4</i> of type <i>Datatype</i>
<i>REAL8</i>	Object <i>REAL8</i> of type <i>Datatype</i>
<i>REAL16</i>	Object <i>REAL16</i> of type <i>Datatype</i>
<i>COMPLEX4</i>	Object <i>COMPLEX4</i> of type <i>Datatype</i>
<i>COMPLEX8</i>	Object <i>COMPLEX8</i> of type <i>Datatype</i>
<i>COMPLEX16</i>	Object <i>COMPLEX16</i> of type <i>Datatype</i>
<i>COMPLEX32</i>	Object <i>COMPLEX32</i> of type <i>Datatype</i>
<i>UNSIGNED_INT</i>	Object <i>UNSIGNED_INT</i> of type <i>Datatype</i>
<i>SIGNED_SHORT</i>	Object <i>SIGNED_SHORT</i> of type <i>Datatype</i>
<i>SIGNED_INT</i>	Object <i>SIGNED_INT</i> of type <i>Datatype</i>
<i>SIGNED_LONG</i>	Object <i>SIGNED_LONG</i> of type <i>Datatype</i>
<i>SIGNED_LONG_LONG</i>	Object <i>SIGNED_LONG_LONG</i> of type <i>Datatype</i>
<i>BOOL</i>	Object <i>BOOL</i> of type <i>Datatype</i>
<i>SINT8_T</i>	Object <i>SINT8_T</i> of type <i>Datatype</i>
<i>SINT16_T</i>	Object <i>SINT16_T</i> of type <i>Datatype</i>
<i>SINT32_T</i>	Object <i>SINT32_T</i> of type <i>Datatype</i>
<i>SINT64_T</i>	Object <i>SINT64_T</i> of type <i>Datatype</i>
<i>F_BOOL</i>	Object <i>F_BOOL</i> of type <i>Datatype</i>
<i>F_INT</i>	Object <i>F_INT</i> of type <i>Datatype</i>
<i>F_FLOAT</i>	Object <i>F_FLOAT</i> of type <i>Datatype</i>
<i>F_DOUBLE</i>	Object <i>F_DOUBLE</i> of type <i>Datatype</i>
<i>F_COMPLEX</i>	Object <i>F_COMPLEX</i> of type <i>Datatype</i>
<i>F_FLOAT_COMPLEX</i>	Object <i>F_FLOAT_COMPLEX</i> of type <i>Datatype</i>
<i>F_DOUBLE_COMPLEX</i>	Object <i>F_DOUBLE_COMPLEX</i> of type <i>Datatype</i>
<i>REQUEST_NULL</i>	Object <i>REQUEST_NULL</i> of type <i>Request</i>
<i>MESSAGE_NULL</i>	Object <i>MESSAGE_NULL</i> of type <i>Message</i>
<i>MESSAGE_NO_PROC</i>	Object <i>MESSAGE_NO_PROC</i> of type <i>Message</i>
<i>OP_NULL</i>	Object <i>OP_NULL</i> of type <i>Op</i>
<i>MAX</i>	Object <i>MAX</i> of type <i>Op</i>
<i>MIN</i>	Object <i>MIN</i> of type <i>Op</i>
<i>SUM</i>	Object <i>SUM</i> of type <i>Op</i>
<i>PROD</i>	Object <i>PROD</i> of type <i>Op</i>
<i>LAND</i>	Object <i>LAND</i> of type <i>Op</i>
<i>BAND</i>	Object <i>BAND</i> of type <i>Op</i>
<i>LOR</i>	Object <i>LOR</i> of type <i>Op</i>
<i>BOR</i>	Object <i>BOR</i> of type <i>Op</i>
<i>LXOR</i>	Object <i>LXOR</i> of type <i>Op</i>
<i>BXOR</i>	Object <i>BXOR</i> of type <i>Op</i>
<i>MAXLOC</i>	Object <i>MAXLOC</i> of type <i>Op</i>
<i>MINLOC</i>	Object <i>MINLOC</i> of type <i>Op</i>
<i>REPLACE</i>	Object <i>REPLACE</i> of type <i>Op</i>

continues on next page

Table 16 – continued from previous page

<i>NO_OP</i>	Object <i>NO_OP</i> of type <i>Op</i>
<i>GROUP_NULL</i>	Object <i>GROUP_NULL</i> of type <i>Group</i>
<i>GROUP_EMPTY</i>	Object <i>GROUP_EMPTY</i> of type <i>Group</i>
<i>INFO_NULL</i>	Object <i>INFO_NULL</i> of type <i>Info</i>
<i>INFO_ENV</i>	Object <i>INFO_ENV</i> of type <i>Info</i>
<i>ERRHANDLER_NULL</i>	Object <i>ERRHANDLER_NULL</i> of type <i>Errhandler</i>
<i>ERRORS_RETURN</i>	Object <i>ERRORS_RETURN</i> of type <i>Errhandler</i>
<i>ERRORS_ARE_FATAL</i>	Object <i>ERRORS_ARE_FATAL</i> of type <i>Errhandler</i>
<i>COMM_NULL</i>	Object <i>COMM_NULL</i> of type <i>Comm</i>
<i>COMM_SELF</i>	Object <i>COMM_SELF</i> of type <i>Intracomm</i>
<i>COMM_WORLD</i>	Object <i>COMM_WORLD</i> of type <i>Intracomm</i>
<i>WIN_NULL</i>	Object <i>WIN_NULL</i> of type <i>Win</i>
<i>FILE_NULL</i>	Object <i>FILE_NULL</i> of type <i>File</i>
<i>pickle</i>	Object <i>pickle</i> of type <i>Pickle</i>

6 mpi4py.typing

Added in version 4.0.0.

This module provides [type aliases](#) used to add [type hints](#) to the various functions and methods within the *MPI* module.

See also

Module `typing`

Documentation of the `typing` standard module.

Types Summary

<i>SupportsBuffer</i>	Python buffer protocol.
<i>SupportsDLPack</i>	DLPack data interchange protocol.
<i>SupportsCAI</i>	CUDA Array Interface (CAI) protocol.
<i>Buffer</i>	Buffer-like object.
<i>Bottom</i>	Start of the address range.
<i>InPlace</i>	In-place buffer argument.
<i>Aint</i>	Address-sized integral type.
<i>Count</i>	Integral type for counts.
<i>Displ</i>	Integral type for displacements.
<i>Offset</i>	Integral type for offsets.
<i>TypeSpec</i>	Datatype specification.
<i>BufSpec</i>	Buffer specification.
<i>BufSpecB</i>	Buffer specification (block).
<i>BufSpecV</i>	Buffer specification (vector).
<i>BufSpecW</i>	Buffer specification (generalized).
<i>TargetSpec</i>	Target specification.

Types Documentation

`mpi4py.typing.SupportsBuffer` = <class 'mpi4py.typing.SupportsBuffer'>

Python buffer protocol.

➔ See also

[Buffer Protocol](#)

`mpi4py.typing.SupportsDLPack` = <class 'mpi4py.typing.SupportsDLPack'>

DLPack data interchange protocol.

➔ See also

[Python Specification for DLPack](#)

`mpi4py.typing.SupportsCAI` = <class 'mpi4py.typing.SupportsCAI'>

CUDA Array Interface (CAI) protocol.

➔ See also

[CUDA Array Interface \(Version 3\)](#)

`mpi4py.typing.Buffer`

Buffer-like object.

alias of [SupportsBuffer](#) | [SupportsDLPack](#) | [SupportsCAI](#)

`mpi4py.typing.Bottom`

Start of the address range.

alias of [BottomType](#) | `None`

`mpi4py.typing.InPlace`

In-place buffer argument.

alias of [InPlaceType](#) | `None`

`mpi4py.typing.Aint` = <class 'typing.SupportsIndex'>

Address-sized integral type.

alias of [SupportsIndex](#)

`mpi4py.typing.Count` = <class 'typing.SupportsIndex'>

Integral type for counts.

alias of [SupportsIndex](#)

`mpi4py.typing.Displ` = <class 'typing.SupportsIndex'>

Integral type for displacements.

alias of [SupportsIndex](#)

`mpi4py.typing.Offset` = <class 'typing.SupportsIndex'>

Integral type for offsets.

alias of `SupportsIndex`

`mpi4py.typing.TypeSpec`

Datatype specification.

alias of `Datatype` | `str`

`mpi4py.typing.BufSpec`

Buffer specification.

- `Buffer`
- `Tuple[Buffer, Count]`
- `Tuple[Buffer, TypeSpec]`
- `Tuple[Buffer, Count, TypeSpec]`
- `Tuple[Bottom, Count, Datatype]`

alias of `SupportsBuffer` | `SupportsDLPack` | `SupportsCAI` | `Tuple[SupportsBuffer` | `SupportsDLPack` | `SupportsCAI, SupportsIndex`] | `Tuple[SupportsBuffer` | `SupportsDLPack` | `SupportsCAI, Datatype` | `str`] | `Tuple[SupportsBuffer` | `SupportsDLPack` | `SupportsCAI, SupportsIndex, Datatype` | `str`] | `Tuple[BottomType` | `None, SupportsIndex, Datatype`] | `List[Any]`

`mpi4py.typing.BufSpecB`

Buffer specification (block).

- `Buffer`
- `Tuple[Buffer, Count]`
- `Tuple[Buffer, TypeSpec]`
- `Tuple[Buffer, Count, TypeSpec]`

alias of `SupportsBuffer` | `SupportsDLPack` | `SupportsCAI` | `Tuple[SupportsBuffer` | `SupportsDLPack` | `SupportsCAI, SupportsIndex`] | `Tuple[SupportsBuffer` | `SupportsDLPack` | `SupportsCAI, Datatype` | `str`] | `Tuple[SupportsBuffer` | `SupportsDLPack` | `SupportsCAI, SupportsIndex, Datatype` | `str`] | `List[Any]`

`mpi4py.typing.BufSpecV`

Buffer specification (vector).

- `Buffer`
- `Tuple[Buffer, Sequence[Count]]`
- `Tuple[Buffer, Tuple[Sequence[Count], Sequence[Displ]]]`
- `Tuple[Buffer, TypeSpec]`
- `Tuple[Buffer, Sequence[Count], TypeSpec]`
- `Tuple[Buffer, Tuple[Sequence[Count], Sequence[Displ]], TypeSpec]`
- `Tuple[Buffer, Sequence[Count], Sequence[Displ], TypeSpec]`
- `Tuple[Bottom, Tuple[Sequence[Count], Sequence[Displ]], Datatype]`
- `Tuple[Bottom, Sequence[Count], Sequence[Displ], Datatype]`

alias of `SupportsBuffer` | `SupportsDLPack` | `SupportsCAI` | `Tuple[SupportsBuffer | SupportsDLPack | SupportsCAI, Sequence[SupportsIndex]]` | `Tuple[SupportsBuffer | SupportsDLPack | SupportsCAI, Tuple[Sequence[SupportsIndex], Sequence[SupportsIndex]]]` | `Tuple[SupportsBuffer | SupportsDLPack | SupportsCAI, Datatype | str]` | `Tuple[SupportsBuffer | SupportsDLPack | SupportsCAI, Sequence[SupportsIndex], Datatype | str]` | `Tuple[SupportsBuffer | SupportsDLPack | SupportsCAI, Tuple[Sequence[SupportsIndex], Sequence[SupportsIndex]], Datatype | str]` | `Tuple[SupportsBuffer | SupportsDLPack | SupportsCAI, Sequence[SupportsIndex], Sequence[SupportsIndex], Datatype | str]` | `Tuple[BottomType | None, Tuple[Sequence[SupportsIndex], Sequence[SupportsIndex]], Datatype]` | `Tuple[BottomType | None, Sequence[SupportsIndex], Sequence[SupportsIndex], Datatype]` | `List[Any]`

`mpi4py.typing.BufSpecW`

Buffer specification (generalized).

- `Tuple[Buffer, Sequence[Datatype]]`
- `Tuple[Buffer, Tuple[Sequence[Count], Sequence[Displ]], Sequence[Datatype]]`
- `Tuple[Buffer, Sequence[Count], Sequence[Displ], Sequence[Datatype]]`
- `Tuple[Bottom, Tuple[Sequence[Count], Sequence[Displ]], Sequence[Datatype]]`
- `Tuple[Bottom, Sequence[Count], Sequence[Displ], Sequence[Datatype]]`

alias of `Tuple[SupportsBuffer | SupportsDLPack | SupportsCAI, Sequence[Datatype]]` | `Tuple[SupportsBuffer | SupportsDLPack | SupportsCAI, Tuple[Sequence[SupportsIndex], Sequence[SupportsIndex]], Sequence[Datatype]]` | `Tuple[SupportsBuffer | SupportsDLPack | SupportsCAI, Sequence[SupportsIndex], Sequence[SupportsIndex], Sequence[Datatype]]` | `Tuple[BottomType | None, Tuple[Sequence[SupportsIndex], Sequence[SupportsIndex]], Sequence[Datatype]]` | `Tuple[BottomType | None, Sequence[SupportsIndex], Sequence[SupportsIndex], Sequence[Datatype]]` | `List[Any]`

`mpi4py.typing.TargetSpec`

Target specification.

- `Displ`
- `Tuple[()]`
- `Tuple[Displ]`
- `Tuple[Displ, Count]`
- `Tuple[Displ, Count, TypeSpec]`

alias of `SupportsIndex` | `Tuple` | `Tuple[SupportsIndex]` | `Tuple[SupportsIndex, SupportsIndex]` | `Tuple[SupportsIndex, SupportsIndex, Datatype | str]` | `List[Any]`

`mpi4py.typing.S = TypeVar("S")`

Invariant TypeVar.

`mpi4py.typing.T = TypeVar("T")`

Invariant TypeVar.

`mpi4py.typing.U = TypeVar("U")`

Invariant TypeVar.

`mpi4py.typing.V = TypeVar("V")`

Invariant TypeVar.

7 mpi4py.futures

Added in version 3.0.0.

This package provides a high-level interface for asynchronously executing callables on a pool of worker processes using MPI for inter-process communication.

The `mpi4py.futures` package is based on `concurrent.futures` from the Python standard library. More precisely, `mpi4py.futures` provides the `MPIPoolExecutor` class as a concrete implementation of the abstract class `Executor`. The `submit()` interface schedules a callable to be executed asynchronously and returns a `Future` object representing the execution of the callable. `Future` instances can be queried for the call result or exception. Sets of `Future` instances can be passed to the `wait()` and `as_completed()` functions.

➔ See also

Module `concurrent.futures`

Documentation of the `concurrent.futures` standard module.

7.1 MPIPoolExecutor

The `MPIPoolExecutor` class uses a pool of MPI processes to execute calls asynchronously. By performing computations in separate processes, it allows to side-step the `global interpreter lock` but also means that only picklable objects can be executed and returned. The `__main__` module must be importable by worker processes, thus `MPIPoolExecutor` instances may not work in the interactive interpreter.

`MPIPoolExecutor` takes advantage of the dynamic process management features introduced in the MPI-2 standard. In particular, the `MPI.Intracomm.Spawn` method of `MPI.COMM_SELF` is used in the master (or parent) process to spawn new worker (or child) processes running a Python interpreter. The master process uses a separate thread (one for each `MPIPoolExecutor` instance) to communicate back and forth with the workers. The worker processes serve the execution of tasks in the main (and only) thread until they are signaled for completion.

i Note

The worker processes must import the main script in order to *unpickle* any callable defined in the `__main__` module and submitted from the master process. Furthermore, the callables may need access to other global variables. At the worker processes, `mpi4py.futures` executes the main script code (using the `runpy` module) under the `__worker__` namespace to define the `__main__` module. The `__main__` and `__worker__` modules are added to `sys.modules` (both at the master and worker processes) to ensure proper *pickling* and *unpickling*.

⚠ Warning

During the initial import phase at the workers, the main script cannot create and use new `MPIPoolExecutor` instances. Otherwise, each worker would attempt to spawn a new pool of workers, leading to infinite recursion. `mpi4py.futures` detects such recursive attempts to spawn new workers and aborts the MPI execution environment. As the main script code is run under the `__worker__` namespace, the easiest way to avoid spawn recursion is using the idiom `if __name__ == '__main__': ...` in the main script.

class `mpi4py.futures.MPIPoolExecutor`(*max_workers=None, initializer=None, initargs=(), **kwargs*)

An `Executor` subclass that executes calls asynchronously using a pool of at most `max_workers` processes. If `max_workers` is `None` or not given, its value is determined from the `MPI4PY_FUTURES_MAX_WORKERS` environment variable if set, or the MPI universe size if set, otherwise a single worker process is spawned. If `max_workers` is lower than or equal to 0, then a `ValueError` will be raised.

initializer is an optional callable that is called at the start of each worker process before executing any tasks; *initargs* is a tuple of arguments passed to the initializer. If *initializer* raises an exception, all pending tasks and any attempt to submit new tasks to the pool will raise a `BrokenExecutor` exception.

Other parameters:

- *python_exe*: Path to the Python interpreter executable used to spawn worker processes, otherwise `sys.executable` is used.
- *python_args*: `list` or iterable with additional command line flags to pass to the Python executable. Command line flags determined from inspection of `sys.flags`, `sys.warnoptions` and `sys._xoptions` in are passed unconditionally.
- *mpi_info*: `dict` or iterable yielding (key, value) pairs. These (key, value) pairs are passed (through an `MPI.Info` object) to the `MPI.Intracomm.Spawn` call used to spawn worker processes. This mechanism allows telling the MPI runtime system where and how to start the processes. Check the documentation of the backend MPI implementation about the set of keys it interprets and the corresponding format for values.
- *globals*: `dict` or iterable yielding (name, value) pairs to initialize the main module namespace in worker processes.
- *main*: If set to `False`, do not import the `__main__` module in worker processes. Setting *main* to `False` prevents worker processes from accessing definitions in the parent `__main__` namespace.
- *path*: `list` or iterable with paths to append to `sys.path` in worker processes to extend the `module search path`.
- *wdir*: Path to set the current working directory in worker processes using `os.chdir()`. The initial working directory is set by the MPI implementation. Quality MPI implementations should honor a *wdir* info key passed through *mpi_info*, although such feature is not mandatory.
- *env*: `dict` or iterable yielding (name, value) pairs with environment variables to update `os.environ` in worker processes. The initial environment is set by the MPI implementation. MPI implementations may allow setting the initial environment through *mpi_info*, however such feature is not required nor recommended by the MPI standard.
- *use_pkl5*: If set to `True`, use `pickle` with out-of-band buffers for interprocess communication. If *use_pkl5* is set to `None` or not given, its value is determined from the `MPI4PY_FUTURES_USE_PKL5` environment variable. Using `pickle` with out-of-band buffers may benefit applications dealing with large buffer-like objects like NumPy arrays. See `mpi4py.util.pkl5` for additional information.
- *backoff*: `float` value specifying the maximum number of seconds a worker thread or process suspends execution with `time.sleep()` while idle-waiting. If not set, its value is determined from the `MPI4PY_FUTURES_BACKOFF` environment variable if set, otherwise the default value of 0.001 seconds is used. Lower values will reduce latency and increase execution throughput for very short-lived tasks, albeit at the expense of spinning CPU cores and increased energy consumption.

submit(*fn*, / (Positional-only parameter separator (PEP 570)), *args, **kwargs)

Schedule the callable *fn* to be executed as `fn(*args, **kwargs)` and returns a `Future` object representing the execution of the callable.

```
executor = MPIPoolExecutor(max_workers=1)
future = executor.submit(pow, 321, 1234)
print(future.result())
```

map(*fn*, *iterables, timeout=None, chunksize=1, buffersize=None, **kwargs)

Similar to `map(fn, *iterables)` except:

- The *iterables* are consumed immediately rather than lazily, unless *buffer_size* is specified to limit the number of submitted tasks whose results have not yet been yielded. If the task buffer is full, the caller blocks and iteration over the *iterables* pauses until a result is yielded from the buffer.
- *fn* is executed asynchronously and several calls to *fn* may be made concurrently, out-of-order, in separate processes.

The returned iterator raises a `TimeoutError` if `__next__()` is called and the result isn't available after *timeout* seconds from the original call to `map()`. *timeout* can be an int or a float. If *timeout* is not specified or `None`, there is no limit to the wait time.

If *fn* raises an exception, then that exception will be raised when its value is retrieved from the iterator.

This method chops *iterables* into a number of chunks which it submits to the pool as separate tasks. The (approximate) size of these chunks can be specified by setting *chunksize* to a positive integer. For very long iterables, using a large value for *chunksize* can significantly improve performance compared to the default size of one.

By default, the returned iterator yields results in-order, waiting for successive tasks to complete. This behavior can be changed by passing the keyword argument *unordered* as `True`, then the result iterator will yield a result as soon as any of the tasks complete.

```
executor = MPIPoolExecutor(max_workers=3)
for result in executor.map(pow, [2] * 32, range(32)):
    print(result)
```

Changed in version 4.1.0: Added the *buffer_size* parameter.

starmap(*fn, iterable, timeout=None, chunksize=1, buffer_size=None, **kwargs*)

Similar to `itertools.starmap(fn, iterable)`. Used instead of `map()` when argument parameters are already grouped in tuples from a single iterable (the data has been “pre-zipped”). `map(fn, *iterable)` is equivalent to `starmap(fn, zip(*iterable))`.

```
executor = MPIPoolExecutor(max_workers=3)
iterable = ((2, n) for n in range(32))
for result in executor.starmap(pow, iterable):
    print(result)
```

Changed in version 4.1.0: Added the *buffer_size* parameter.

shutdown(*wait=True, cancel_futures=False*)

Signal the executor that it should free any resources that it is using when the currently pending futures are done executing. Calls to `submit()` and `map()` made after `shutdown()` will raise `RuntimeError`.

If *wait* is `True` then this method will not return until all the pending futures are done executing and the resources associated with the executor have been freed. If *wait* is `False` then this method will return immediately and the resources associated with the executor will be freed when all pending futures are done executing. Regardless of the value of *wait*, the entire Python program will not exit until all pending futures are done executing.

If *cancel_futures* is `True`, this method will cancel all pending futures that the executor has not started running. Any futures that are completed or running won't be cancelled, regardless of the value of *cancel_futures*.

You can avoid having to call this method explicitly if you use the `with` statement, which will shutdown the executor instance (waiting as if `shutdown()` were called with *wait* set to `True`).

```
import time
with MPIPoolExecutor(max_workers=1) as executor:
    future = executor.submit(time.sleep, 2)
assert future.done()
```

`bootup(wait=True)`

Signal the executor that it should allocate eagerly any required resources (in particular, MPI worker processes). If `wait` is `True`, then `bootup()` will not return until the executor resources are ready to process submissions. Resources are automatically allocated in the first call to `submit()`, thus calling `bootup()` explicitly is seldom needed.

`num_workers`

Number or worker processes in the pool.

`MPI4PY_FUTURES_MAX_WORKERS`

If the `max_workers` parameter to `MPIPoolExecutor` is `None` or not given, the `MPI4PY_FUTURES_MAX_WORKERS` environment variable provides a fallback value for the maximum number of MPI worker processes to spawn.

Added in version 3.1.0.

`MPI4PY_FUTURES_USE_PKL5`

If the `use_pkl5` keyword argument to `MPIPoolExecutor` is `None` or not given, the `MPI4PY_FUTURES_USE_PKL5` environment variable provides a fallback value for whether the executor should use `pickle` with out-of-band buffers for interprocess communication. Accepted values are `0` and `1` (interpreted as `False` and `True`, respectively), and strings specifying a `YAML boolean` value (case-insensitive). Using `pickle` with out-of-band buffers may benefit applications dealing with large buffer-like objects like NumPy arrays. See `mpi4py.util.pkl5` for additional information.

Added in version 4.0.0.

`MPI4PY_FUTURES_BACKOFF`

If the `backoff` keyword argument to `MPIPoolExecutor` is not given, the `MPI4PY_FUTURES_BACKOFF` environment variable can be set to a `float` value specifying the maximum number of seconds a worker thread or process suspends execution with `time.sleep()` while idle-waiting. If not set, the default backoff value is 0.001 seconds. Lower values will reduce latency and increase execution throughput for very short-lived tasks, albeit at the expense of spinning CPU cores and increased energy consumption.

Added in version 4.0.0.

Note

As the master process uses a separate thread to perform MPI communication with the workers, the backend MPI implementation should provide support for `MPI.THREAD_MULTIPLE`. However, some popular MPI implementations do not support yet concurrent MPI calls from multiple threads. Additionally, users may decide to initialize MPI with a lower level of thread support. If the level of thread support in the backend MPI is less than `MPI.THREAD_MULTIPLE`, `mpi4py.futures` will use a global lock to serialize MPI calls. If the level of thread support is less than `MPI.THREAD_SERIALIZED`, `mpi4py.futures` will emit a `RuntimeWarning`.

Warning

If the level of thread support in the backend MPI is less than `MPI.THREAD_SERIALIZED` (i.e. it is either `MPI.THREAD_SINGLE` or `MPI.THREAD_FUNNELED`), in theory `mpi4py.futures` cannot be used. Rather than raising

an exception, `mpi4py.futures` emits a warning and takes a “cross-fingers” attitude to continue execution in the hope that serializing MPI calls with a global lock will actually work.

7.2 MPICommExecutor

Legacy MPI-1 implementations (as well as some vendor MPI-2 implementations) do not support the dynamic process management features introduced in the MPI-2 standard. Additionally, job schedulers and batch systems in supercomputing facilities may pose additional complications to applications using the `MPI_Comm_spawn()` routine.

With these issues in mind, `mpi4py.futures` supports an additional, more traditional, SPMD-like usage pattern requiring MPI-1 calls only. Python applications are started the usual way, e.g., using the `mpiexec` command. Python code should make a collective call to the `MPICommExecutor` context manager to partition the set of MPI processes within a MPI communicator in one master processes and many workers processes. The master process gets access to an `MPIPoolExecutor` instance to submit tasks. Meanwhile, the worker process follow a different execution path and team-up to execute the tasks submitted from the master.

Besides alleviating the lack of dynamic process management features in legacy MPI-1 or partial MPI-2 implementations, the `MPICommExecutor` context manager may be useful in classic MPI-based Python applications willing to take advantage of the simple, task-based, master/worker approach available in the `mpi4py.futures` package.

```
class mpi4py.futures.MPICommExecutor(comm=None, root=0)
```

Context manager for `MPIPoolExecutor`. This context manager splits a MPI (intra)communicator `comm` (defaults to `MPI.COMM_WORLD` if not provided or `None`) in two disjoint sets: a single master process (with rank `root` in `comm`) and the remaining worker processes. These sets are then connected through an intercommunicator. The target of the `with` statement is assigned either an `MPIPoolExecutor` instance (at the master) or `None` (at the workers).

```
from mpi4py import MPI
from mpi4py.futures import MPICommExecutor

with MPICommExecutor(MPI.COMM_WORLD, root=0) as executor:
    if executor is not None:
        future = executor.submit(abs, -42)
        assert future.result() == 42
        answer = set(executor.map(abs, [-42, 42]))
        assert answer == {42}
```

Warning

If `MPICommExecutor` is passed a communicator of size one (e.g., `MPI.COMM_SELF`), then the executor instance assigned to the target of the `with` statement will execute all submitted tasks in a single worker thread, thus ensuring that task execution still progress asynchronously. However, the `GIL` will prevent the main and worker threads from running concurrently in multicore processors. Moreover, the thread context switching may harm noticeably the performance of CPU-bound tasks. In case of I/O-bound tasks, the `GIL` is not usually an issue, however, as a single worker thread is used, it progress one task at a time. We advice against using `MPICommExecutor` with communicators of size one and suggest refactoring your code to use instead a `ThreadPoolExecutor`.

7.3 Command line

Recalling the issues related to the lack of support for dynamic process management features in MPI implementations, `mpi4py.futures` supports an alternative usage pattern where Python code (either from scripts, modules, or zip files) is run under command line control of the `mpi4py.futures` package by passing `-m mpi4py.futures` to the `python` executable. The `mpi4py.futures` invocation should be passed a `pyfile` path to a script (or a zipfile/directory containing

a `__main__.py` file). Additionally, `mpi4py.futures` accepts `-m mod` to execute a module named `mod`, `-c cmd` to execute a command string `cmd`, or even `-` to read commands from standard input (`sys.stdin`). Summarizing, `mpi4py.futures` can be invoked in the following ways:

- `$ mpiexec -n numprocs python -m mpi4py.futures pyfile [arg] ...`
- `$ mpiexec -n numprocs python -m mpi4py.futures -m mod [arg] ...`
- `$ mpiexec -n numprocs python -m mpi4py.futures -c cmd [arg] ...`
- `$ mpiexec -n numprocs python -m mpi4py.futures - [arg] ...`

Before starting the main script execution, `mpi4py.futures` splits `MPI.COMM_WORLD` in one master (the process with rank 0 in `MPI.COMM_WORLD`) and `numprocs - 1` workers and connects them through an MPI intercommunicator. Afterwards, the master process proceeds with the execution of the user script code, which eventually creates `MPIPoolExecutor` instances to submit tasks. Meanwhile, the worker processes follow a different execution path to serve the master. Upon successful termination of the main script at the master, the entire MPI execution environment exists gracefully. In case of any unhandled exception in the main script, the master process calls `MPI.COMM_WORLD.Abort(1)` to prevent deadlocks and force termination of entire MPI execution environment.

Warning

Running scripts under command line control of `mpi4py.futures` is quite similar to executing a single-process application that spawn additional workers as required. However, there is a very important difference users should be aware of. All `MPIPoolExecutor` instances created at the master will share the pool of workers. Tasks submitted at the master from many different executors will be scheduled for execution in random order as soon as a worker is idle. Any executor can easily starve all the workers (e.g., by calling `MPIPoolExecutor.map()` with long iterables). If that ever happens, submissions from other executors will not be serviced until free workers are available.

See also

Command line

Documentation on Python command line interface.

7.4 Parallel tasks

The `mpi4py.futures` package favors an embarrassingly parallel execution model involving a series of sequential tasks independent of each other and executed asynchronously. Albeit unnatural, `MPIPoolExecutor` can still be used for handling workloads involving parallel tasks, where worker processes communicate and coordinate each other via MPI.

`mpi4py.futures.get_comm_workers()`

Access an intracommunicator grouping MPI worker processes.

Executing parallel tasks with `mpi4py.futures` requires following some rules, cf. highlighted lines in example `cpi.py`:

- Use `MPIPoolExecutor.num_workers` to determine the number of worker processes in the executor and **submit exactly one callable per worker process** using the `MPIPoolExecutor.submit()` method.
- The submitted callable must use `get_comm_workers()` to access an intracommunicator grouping MPI worker processes. Afterwards, it is highly recommended calling the `Barrier()` method on the communicator. The barrier synchronization ensures that every worker process is executing the submitted callable exactly once. Afterwards, the parallel task can safely perform any kind of point-to-point or collective operation using the returned communicator.

- The `Future` instances returned by `MPIPoolExecutor.submit()` should be collected in a sequence. Use `wait()` with the sequence of `Future` instances to ensure logical completion of the parallel task.

7.5 Utilities

The `mpi4py.futures` package provides additional utilities for handling `Future` instances.

`mpi4py.futures.collect(fs)`

Gather a collection of futures in a new future.

Parameters

fs – Collection of futures.

Returns

New future producing as result a list with results from `fs`.

`mpi4py.futures.compose(future, resulthook=None, excepthook=None)`

Compose the completion of a future with result and exception handlers.

Parameters

- **future** – Input future instance.
- **resulthook** – Function to be called once the input future completes with success. Once the input future finish running with success, its result value is the input argument for `resulthook`. The result of `resulthook` is set as the result of the output future. If `resulthook` is `None`, the output future is completed directly with the result of the input future.
- **excepthook** – Function to be called once the input future completes with failure. Once the input future finish running with failure, its exception value is the input argument for `excepthook`. If `excepthook` returns an `Exception` instance, it is set as the exception of the output future. Otherwise, the result of `excepthook` is set as the result of the output future. If `excepthook` is `None`, the output future is set as failed with the exception from the input future.

Returns

Output future instance to be completed once the input future is completed and either `resulthook` or `excepthook` finish executing.

7.6 Examples

Computing the Julia set

The following `julia.py` script computes the **Julia set** and dumps an image to disk in binary **PGM** format. The code starts by importing `MPIPoolExecutor` from the `mpi4py.futures` package. Next, some global constants and functions implement the computation of the Julia set. The computations are protected with the standard `if __name__ == '__main__': ...` idiom. The image is computed by whole scanlines submitting all these tasks at once using the `map` method. The result iterator yields scanlines in-order as the tasks complete. Finally, each scanline is dumped to disk.

Listing 1: `julia.py`

```

1 from mpi4py.futures import MPIPoolExecutor
2
3 x0, x1, w = -2.0, +2.0, 640*2
4 y0, y1, h = -1.5, +1.5, 480*2
5 dx = (x1 - x0) / w
6 dy = (y1 - y0) / h
7

```

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```
8 c = complex(0, 0.65)
9
10 def julia(x, y):
11     z = complex(x, y)
12     n = 255
13     while abs(z) < 3 and n > 1:
14         z = z**2 + c
15         n -= 1
16     return n
17
18 def julia_line(k):
19     line = bytearray(w)
20     y = y1 - k * dy
21     for j in range(w):
22         x = x0 + j * dx
23         line[j] = julia(x, y)
24     return line
25
26 if __name__ == '__main__':
27
28     with MPIPoolExecutor() as executor:
29         image = executor.map(julia_line, range(h))
30         with open('julia.pgm', 'wb') as f:
31             f.write(b'P5 %d %d %d\n' % (w, h, 255))
32             for line in image:
33                 f.write(line)
```

The recommended way to execute the script is by using the `mpiexec` command specifying one MPI process (master) and (optional but recommended) the desired MPI universe size, which determines the number of additional dynamically spawned processes (workers). The MPI universe size is provided either by a batch system or set by the user via command-line arguments to `mpiexec` or environment variables. Below we provide examples for MPICH and Open MPI implementations¹. In all of these examples, the `mpiexec` command launches a single master process running the Python interpreter and executing the main script. When required, `mpi4py.futures` spawns the pool of 16 worker processes. The master submits tasks to the workers and waits for the results. The workers receive incoming tasks, execute them, and send back the results to the master.

When using MPICH implementation or its derivatives based on the Hydra process manager, users can set the MPI universe size via the `-usize` argument to `mpiexec`:

```
$ mpiexec -n 1 -usize 17 python julia.py
```

or, alternatively, by setting the `MPIEXEC_UNIVERSE_SIZE` environment variable:

```
$ env MPIEXEC_UNIVERSE_SIZE=17 mpiexec -n 1 python julia.py
```

In the Open MPI implementation, the MPI universe size can be set via the `-host` argument to `mpiexec`:

```
$ mpiexec -n 1 -host localhost:17 python julia.py
```

Another way to specify the number of workers is to use the `mpi4py.futures`-specific environment variable `MPI4PY_FUTURES_MAX_WORKERS`:

¹ When using an MPI implementation other than MPICH or Open MPI, please check the documentation of the implementation and/or batch system for the ways to specify the desired MPI universe size.

```
$ env MPI4PY_FUTURES_MAX_WORKERS=16 mpiexec -n 1 python julia.py
```

Note that in this case, the MPI universe size is ignored.

Alternatively, users may decide to execute the script in a more traditional way, that is, all the MPI processes are started at once. The user script is run under command-line control of `mpi4py.futures` passing the `-m` flag to the `python` executable:

```
$ mpiexec -n 17 python -m mpi4py.futures julia.py
```

As explained previously, the 17 processes are partitioned in one master and 16 workers. The master process executes the main script while the workers execute the tasks submitted by the master.

Computing Pi (parallel task)

The number π can be approximated via numerical integration with the simple midpoint rule, that is:

$$\pi = \int_0^1 \frac{4}{1+x^2} dx \approx \frac{1}{n} \sum_{i=1}^n \frac{4}{1 + \left[\frac{1}{n} \left(i - \frac{1}{2}\right)\right]^2}.$$

The following `cpi.py` script computes such approximations using `mpi4py.futures` with a parallel task involving a collective reduction operation. Highlighted lines correspond to the rules discussed in *Parallel tasks*.

Listing 2: `cpi.py`

```
1 import math
2 import sys
3 from mpi4py.futures import MPIPoolExecutor, wait
4 from mpi4py.futures import get_comm_workers
5
6
7 def compute_pi(n):
8     # Access intracommunicator and synchronize
9     comm = get_comm_workers()
10    comm.Barrier()
11
12    rank = comm.Get_rank()
13    size = comm.Get_size()
14
15    # Local computation
16    h = 1.0 / n
17    s = 0.0
18    for i in range(rank + 1, n + 1, size):
19        x = h * (i - 0.5)
20        s += 4.0 / (1.0 + x**2)
21    pi_partial = s * h
22
23    # Parallel reduce-to-all
24    pi = comm.allreduce(pi_partial)
25
26    # All workers return the same value
27    return pi
28
29
```

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```
30 if __name__ == '__main__':
31     n = int(sys.argv[1]) if len(sys.argv) > 1 else 256
32
33     with MPIPoolExecutor() as executor:
34         # Submit exactly one callable per worker
35         P = executor.num_workers
36         fs = [executor.submit(compute_pi, n) for _ in range(P)]
37
38         # Wait for all workers to finish
39         wait(fs)
40
41         # Get result from the first future object.
42         # In this particular example, due to using reduce-to-all,
43         # all the other future objects hold the same result value.
44         pi = fs[0].result()
45         print(
46             f"pi: {pi:.16f}, error: {abs(pi - math.pi):.3e}",
47             f"({n:d} intervals, {P:d} workers)",
48         )
```

To run in modern MPI-2 mode:

```
$ env MPI4PY_FUTURES_MAX_WORKERS=4 mpiexec -n 1 python cpi.py 128
pi: 3.1415977398528137, error: 5.086e-06 (128 intervals, 4 workers)

$ env MPI4PY_FUTURES_MAX_WORKERS=8 mpiexec -n 1 python cpi.py 512
pi: 3.1415929714812316, error: 3.179e-07 (512 intervals, 8 workers)
```

To run in legacy MPI-1 mode:

```
$ mpiexec -n 5 python -m mpi4py.futures cpi.py 128
pi: 3.1415977398528137, error: 5.086e-06 (128 intervals, 4 workers)

$ mpiexec -n 9 python -m mpi4py.futures cpi.py 512
pi: 3.1415929714812316, error: 3.179e-07 (512 intervals, 8 workers)
```

7.7 Citation

If *mpi4py.futures* been significant to a project that leads to an academic publication, please acknowledge our work by citing the following article [[mpi4py-futures](#)]:

8 mpi4py.util

Added in version 3.1.0.

The *mpi4py.util* package collects miscellaneous utilities within the intersection of Python and MPI.

8.1 mpi4py.util.dtlb

Added in version 3.1.0.

The *mpi4py.util.dtlb* module provides converter routines between NumPy and MPI datatypes.

`mpi4py.util.dtlib.from_numpy_dtype(dtype)`

Convert NumPy datatype to MPI datatype.

Parameters

dtype (*DTypeLike*) – NumPy dtype-like object.

Return type

Datatype

`mpi4py.util.dtlib.to_numpy_dtype(datatype)`

Convert MPI datatype to NumPy datatype.

Parameters

datatype (*Datatype*) – MPI datatype.

Return type

dtype[*Any*]

8.2 `mpi4py.util.pk15`

Added in version 3.1.0.

`pickle` protocol 5 (see [PEP 574](#)) introduced support for out-of-band buffers, allowing for more efficient handling of certain object types with large memory footprints.

MPI for Python uses the traditional in-band handling of buffers. This approach is appropriate for communicating non-buffer Python objects, or buffer-like objects with small memory footprints. For point-to-point communication, in-band buffer handling allows for the communication of a pickled stream with a single MPI message, at the expense of additional CPU and memory overhead in the pickling and unpickling steps.

The `mpi4py.util.pk15` module provides communicator wrapper classes reimplementing pickle-based point-to-point and collective communication methods using pickle protocol 5. Handling out-of-band buffers necessarily involves multiple MPI messages, thus increasing latency and hurting performance in case of small size data. However, in case of large size data, the zero-copy savings of out-of-band buffer handling more than offset the extra latency costs. Additionally, these wrapper methods overcome the infamous 2 GiB message count limit (MPI-1 to MPI-3).

class `mpi4py.util.pk15.Request`

Request.

Custom request class for nonblocking communications.

Note

`Request` is not a subclass of `mpi4py.MPI.Request`

Free()

Free a communication request.

Return type

None

free()

Free a communication request.

Return type

None

cancel()

Cancel a communication request.

Return type

`None`

get_status(status=None)

Non-destructive test for the completion of a request.

Parameters

status (`Status` | `None`)

Return type

`bool`

test(status=None)

Test for the completion of a request.

Parameters

status (`Status` | `None`)

Return type

`tuple[bool, Any | None]`

wait(status=None)

Wait for a request to complete.

Parameters

status (`Status` | `None`)

Return type

`Any`

classmethod get_status_all(requests, statuses=None)

Non-destructive test for the completion of all requests.

Classmethod

classmethod testall(requests, statuses=None)

Test for the completion of all requests.

Classmethod

classmethod waitall(requests, statuses=None)

Wait for all requests to complete.

Classmethod

class mpi4py.util.pk15.Message

Message.

Custom message class for matching probes.

Note

Message is not a subclass of *mpi4py.MPI.Message*

free()

Do nothing.

Return type

None

recv(*status=None*)

Blocking receive of matched message.

Parameters

status (*Status* / *None*)

Return type

Any

irecv()

Nonblocking receive of matched message.

Return type

Request

classmethod probe(*comm, source=ANY_SOURCE, tag=ANY_TAG, status=None*)

Blocking test for a matched message.

Classmethod

classmethod iprobe(*comm, source=ANY_SOURCE, tag=ANY_TAG, status=None*)

Nonblocking test for a matched message.

Classmethod

class `mpi4py.util.pk15.Comm`

Communicator.

Base communicator wrapper class.

send(*obj, dest, tag=0*)

Blocking send in standard mode.

Parameters

- **obj** (*Any*)
- **dest** (*int*)
- **tag** (*int*)

Return type

None

bsend(*obj, dest, tag=0*)

Blocking send in buffered mode.

Parameters

- **obj** (*Any*)
- **dest** (*int*)
- **tag** (*int*)

Return type

None

ssend(*obj*, *dest*, *tag=0*)

Blocking send in synchronous mode.

Parameters

- **obj** (*Any*)
- **dest** (*int*)
- **tag** (*int*)

Return type

None

isend(*obj*, *dest*, *tag=0*)

Nonblocking send in standard mode.

Parameters

- **obj** (*Any*)
- **dest** (*int*)
- **tag** (*int*)

Return type

Request

ibsend(*obj*, *dest*, *tag=0*)

Nonblocking send in buffered mode.

Parameters

- **obj** (*Any*)
- **dest** (*int*)
- **tag** (*int*)

Return type

Request

issend(*obj*, *dest*, *tag=0*)

Nonblocking send in synchronous mode.

Parameters

- **obj** (*Any*)
- **dest** (*int*)
- **tag** (*int*)

Return type

Request

recv(*buf=None*, *source=ANY_SOURCE*, *tag=ANY_TAG*, *status=None*)

Blocking receive.

Parameters

- **buf** (*Buffer* | *None*)
- **source** (*int*)
- **tag** (*int*)

- **status** (*Status* | *None*)

Return type

Any

irecv(*buf=None, source=ANY_SOURCE, tag=ANY_TAG*)

Nonblocking receive.

 **Warning**

This method cannot be supported reliably and raises `RuntimeError`.

Parameters

- **buf** (*Buffer* | *None*)
- **source** (*int*)
- **tag** (*int*)

Return type

Request

sendrecv(*sendobj, dest, sendtag=0, recvbuf=None, source=ANY_SOURCE, recvtag=ANY_TAG, status=None*)

Send and receive.

Parameters

- **sendobj** (*Any*)
- **dest** (*int*)
- **sendtag** (*int*)
- **recvbuf** (*Buffer* | *None*)
- **source** (*int*)
- **recvtag** (*int*)
- **status** (*Status* | *None*)

Return type

Any

mprobe(*source=ANY_SOURCE, tag=ANY_TAG, status=None*)

Blocking test for a matched message.

Parameters

- **source** (*int*)
- **tag** (*int*)
- **status** (*Status* | *None*)

Return type

Message

improbe(*source=ANY_SOURCE, tag=ANY_TAG, status=None*)

Nonblocking test for a matched message.

Parameters

- **source** (*int*)
- **tag** (*int*)
- **status** (*Status | None*)

Return type

Message | None

bcast(*obj, root=0*)

Broadcast.

Added in version 3.1.0.

Parameters

- **obj** (*Any*)
- **root** (*int*)

Return type

Any

gather(*sendobj, root=0*)

Gather.

Added in version 4.0.0.

Parameters

- **sendobj** (*Any*)
- **root** (*int*)

Return type

list[Any] | None

scatter(*sendobj, root=0*)

Scatter.

Added in version 4.0.0.

Parameters

- **sendobj** (*Sequence[Any] | None*)
- **root** (*int*)

Return type

Any

allgather(*sendobj*)

Gather to All.

Added in version 4.0.0.

Parameters

sendobj (*Any*)

Return type

list[Any]

alltoall(*sendobj*)

All to All Scatter/Gather.

Added in version 4.0.0.

Parameters

sendobj (*Sequence*[*Any*])

Return type

list[*Any*]

class `mpi4py.util.pk15.Intracomm`

Intracommunicator.

Intracommunicator wrapper class.

class `mpi4py.util.pk15.Intercomm`

Intercommunicator.

Intercommunicator wrapper class.

Examples

Listing 3: test-pk15-1.py

```
1 import numpy as np
2 from mpi4py import MPI
3 from mpi4py.util import pk15
4
5 comm = pk15.Intracomm(MPI.COMM_WORLD) # comm wrapper
6 size = comm.Get_size()
7 rank = comm.Get_rank()
8 dst = (rank + 1) % size
9 src = (rank - 1) % size
10
11 sobj = np.full(1024**3, rank, dtype='i4') # > 4 GiB
12 sreq = comm.isend(sobj, dst, tag=42)
13 robj = comm.recv(None, src, tag=42)
14 sreq.Free()
15
16 assert np.min(robj) == src
17 assert np.max(robj) == src
```

Listing 4: test-pk15-2.py

```
1 import numpy as np
2 from mpi4py import MPI
3 from mpi4py.util import pk15
4
5 comm = pk15.Intracomm(MPI.COMM_WORLD) # comm wrapper
6 size = comm.Get_size()
7 rank = comm.Get_rank()
8 dst = (rank + 1) % size
9 src = (rank - 1) % size
10
11 sobj = np.full(1024**3, rank, dtype='i4') # > 4 GiB
```

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```
12 sreq = comm.isend(sobj, dst, tag=42)
13
14 status = MPI.Status()
15 rmsg = comm.mprobe(status=status)
16 assert status.Get_source() == src
17 assert status.Get_tag() == 42
18 rreq = rmsg.irecv()
19 robj = rreq.wait()
20
21 sreq.Free()
22 assert np.max(robj) == src
23 assert np.min(robj) == src
```

8.3 mpi4py.util.pool

Added in version 4.0.0.

➔ See also

This module intends to be a drop-in replacement for the `multiprocessing.pool` interface from the Python standard library. The `Pool` class exposed here is implemented as a thin wrapper around `MPIPoolExecutor`.

i Note

The `mpi4py.futures` package offers a higher level interface for asynchronously pushing tasks to MPI worker process, allowing for a clear separation between submitting tasks and waiting for the results.

class `mpi4py.util.pool.Pool`

Pool using MPI processes as workers.

`__init__(processes=None, initializer=None, initargs=(), **kwargs)`

Initialize a new Pool instance.

Parameters

- **processes** (`int` | `None`) – Number of worker processes.
- **initializer** (`Callable[[...], object]` | `None`) – An callable used to initialize workers processes.
- **initargs** (`Iterable[Any]`) – A tuple of arguments to pass to the initializer.
- **kwargs** (`Any`)

Return type

`None`

i Note

Additional keyword arguments are passed down to the `MPIPoolExecutor` constructor.

 **Warning**

The `maxtasksperchild` and `context` arguments of `multiprocessing.pool.Pool` are not supported. Specifying `maxtasksperchild` or `context` with a value other than `None` will issue a warning of category `UserWarning`.

apply(*func*, *args*=(), *kwds*={})

Call *func* with arguments *args* and keyword arguments *kwds*.

Equivalent to `func(*args, **kwds)`.

Parameters

- **func** (`Callable[[...], T]`)
- **args** (`Iterable[Any]`)
- **kwds** (`Mapping[str, Any]`)

Return type

`T`

apply_async(*func*, *args*=(), *kwds*={}, *callback*=None, *error_callback*=None)

Asynchronous version of `apply()` returning `ApplyResult`.

Parameters

- **func** (`Callable[... , T]`)
- **args** (`Iterable[Any]`)
- **kwds** (`Mapping[str, Any]`)
- **callback** (`Callable[[T], object] | None`)
- **error_callback** (`Callable[[BaseException], object] | None`)

Return type

`AsyncResult[T]`

map(*func*, *iterable*, *chunksize*=None)

Apply *func* to each element in *iterable*.

Equivalent to `list(map(func, iterable))`.

Block until all results are ready and return them in a `list`.

The *iterable* is chopped into a number of chunks which are submitted as separate tasks. The (approximate) size of these chunks can be specified by setting *chunksize* to a positive integer.

Consider using `imap()` or `imap_unordered()` with explicit *chunksize* for better efficiency.

Parameters

- **func** (`Callable[[S], T]`)
- **iterable** (`Iterable[S]`)
- **chunksize** (`int | None`)

Return type

`list[T]`

map_async(*func*, *iterable*, *chunksize=None*, *callback=None*, *error_callback=None*)

Asynchronous version of *map()* returning *MapResult*.

Parameters

- **func** (*Callable*[[*S*], *T*])
- **iterable** (*Iterable*[*S*])
- **chunksize** (*int* | *None*)
- **callback** (*Callable*[[*T*], *None*] | *None*)
- **error_callback** (*Callable*[[*BaseException*], *None*] | *None*)

Return type

MapResult[*T*]

imap(*func*, *iterable*, *chunksize=1*)

Like *map()* but return an *iterator*.

Equivalent to *map(func, iterable)*.

Parameters

- **func** (*Callable*[[*S*], *T*])
- **iterable** (*Iterable*[*S*])
- **chunksize** (*int*)

Return type

Iterator[*T*]

imap_unordered(*func*, *iterable*, *chunksize=1*)

Like *imap()* but ordering of results is arbitrary.

Parameters

- **func** (*Callable*[[*S*], *T*])
- **iterable** (*Iterable*[*S*])
- **chunksize** (*int*)

Return type

Iterator[*T*]

starmap(*func*, *iterable*, *chunksize=None*)

Apply *func* to each argument tuple in *iterable*.

Equivalent to *list(itertools.starmap(func, iterable))*.

Block until all results are ready and return them in a *list*.

The *iterable* is chopped into a number of chunks which are submitted as separate tasks. The (approximate) size of these chunks can be specified by setting *chunksize* to a positive integer.

Consider using *istarmap()* or *istarmap_unordered()* with explicit *chunksize* for better efficiency.

Parameters

- **func** (*Callable*[[...], *T*])
- **iterable** (*Iterable*[*Iterable*[*Any*]])
- **chunksize** (*int* | *None*)

Return type

`list[T]`

starmap_async(*func*, *iterable*, *chunksize=None*, *callback=None*, *error_callback=None*)

Asynchronous version of `starmap()` returning `MapResult`.

Parameters

- **func** (`Callable[...]`, `T`)
- **iterable** (`Iterable[Iterable[Any]]`)
- **chunksize** (`int` | `None`)
- **callback** (`Callable[[T], None]` | `None`)
- **error_callback** (`Callable[[BaseException], None]` | `None`)

Return type

`MapResult[T]`

istarmap(*func*, *iterable*, *chunksize=1*)

Like `starmap()` but return an `iterator`.

Equivalent to `itertools.starmap(func, iterable)`.

Parameters

- **func** (`Callable[...]`, `T`)
- **iterable** (`Iterable[Iterable[Any]]`)
- **chunksize** (`int`)

Return type

`Iterator[T]`

istarmap_unordered(*func*, *iterable*, *chunksize=1*)

Like `istarmap()` but ordering of results is arbitrary.

Parameters

- **func** (`Callable[...]`, `T`)
- **iterable** (`Iterable[Iterable[Any]]`)
- **chunksize** (`int`)

Return type

`Iterator[T]`

close()

Prevent any more tasks from being submitted to the pool.

Return type

`None`

terminate()

Stop the worker processes without completing pending tasks.

Return type

`None`

join()

Wait for the worker processes to exit.

Return type

None

class mpi4py.util.pool.ThreadPool

Bases: *Pool*

Pool using threads as workers.

class mpi4py.util.pool.AsyncResult

Asynchronous result.

get(timeout=None)

Return the result when it arrives.

If *timeout* is not *None* and the result does not arrive within *timeout* seconds then raise *TimeoutError*.

If the remote call raised an exception then that exception will be reraised.

Parameters

timeout (*float* | *None*)

Return type

T

wait(timeout=None)

Wait until the result is available or *timeout* seconds pass.

Parameters

timeout (*float* | *None*)

Return type

None

ready()

Return whether the call has completed.

Return type

bool

successful()

Return whether the call completed without raising an exception.

If the result is not ready then raise *ValueError*.

Return type

bool

class mpi4py.util.pool.ApplyResult

Bases: *AsyncResult*

Result type of *apply_async()*.

class mpi4py.util.pool.MapResult

Bases: *AsyncResult*

Result type of *map_async()* and *starmap_async()*.

8.4 mpi4py.util.sync

Added in version 4.0.0.

The `mpi4py.util.sync` module provides parallel synchronization utilities.

Sequential execution

class `mpi4py.util.sync.Sequential`

Sequential execution.

Context manager for sequential execution within a group of MPI processes.

The implementation is based in MPI-1 point-to-point communication. A process with rank i waits in a blocking receive until the previous process rank $i-1$ finish executing and signals the next rank i with a send.

__init__(*comm*, *tag=0*)

Initialize sequential execution.

Parameters

- **comm** (`Intracomm`) – Intracommunicator context.
- **tag** (`int`) – Tag for point-to-point communication.

Return type

`None`

__enter__()

Enter sequential execution.

Return type

`Self`

__exit__(**exc*)

Exit sequential execution.

Parameters

exc (`object`)

Return type

`None`

begin()

Begin sequential execution.

Return type

`None`

end()

End sequential execution.

Return type

`None`

Global counter

class `mpi4py.util.sync.Counter`

Global counter.

Produce consecutive values within a group of MPI processes. The counter interface is close to that of `itertools.count`.

The implementation is based in MPI-3 one-sided operations. A root process (typically rank 0) holds the counter, and its value is queried and incremented with an atomic RMA *fetch-and-add* operation.

`__init__(start=0, step=1, *, typecode='i', comm=COMM_SELF, info=INFO_NULL, root=0)`

Initialize global counter.

Parameters

- **start** (*int*) – Start value.
- **step** (*int*) – Increment value.
- **typecode** (*str*) – Type code as defined in the `array` module.
- **comm** (`Intracomm`) – Intracommunicator context.
- **info** (`Info`) – Info object for RMA context creation.
- **root** (*int*) – Process rank holding the counter memory.

Return type

`None`

`__iter__()`

Implement `iter(self)`.

Return type

`Self`

`__next__()`

Implement `next(self)`.

Return type

`int`

`next(incr=None)`

Return current value and increment.

Parameters

incr (*int* | `None`) – Increment value.

Returns

The counter value before incrementing.

Return type

`int`

`free()`

Free counter resources.

Return type

`None`

Mutual exclusion

`class mpi4py.util.sync.Mutex`

Mutual exclusion.

Establish a critical section or mutual exclusion among MPI processes.

The mutex interface is close to that of `threading.Lock` and `threading.RLock`, allowing the use of either recursive or non-recursive mutual exclusion. However, a mutex should be used within a group of MPI processes, not threads.

In non-recursive mode, the semantics of *Mutex* are somewhat different than these of `threading.Lock`:

- Once acquired, a mutex is held and owned by a process until released.
- Trying to acquire a mutex already held raises `RuntimeError`.
- Trying to release a mutex not yet held raises `RuntimeError`.

This mutex implementation uses the scalable and fair spinlock algorithm from [mcs-paper] and took inspiration from the MPI-3 RMA implementation of [uam-book].

`__init__`(*, *recursive=False*, *comm=COMM_SELF*, *info=INFO_NULL*)

Initialize mutex object.

Parameters

- **comm** (*Intracomm*) – Intracommunicator context.
- **recursive** (*bool*) – Whether to allow recursive acquisition.
- **info** (*Info*) – Info object for RMA context creation.

Return type

None

`__enter__`()

Acquire mutex.

Return type

Self

`__exit__`(**exc*)

Release mutex.

Parameters

exc (*object*)

Return type

None

`acquire`(*blocking=True*)

Acquire mutex, blocking or non-blocking.

Parameters

blocking (*bool*) – If `True`, block until the mutex is held.

Returns

`True` if the mutex is held, `False` otherwise.

Return type

bool

`release`()

Release mutex.

Return type

None

`locked`()

Return whether the mutex is held.

Return type

bool

count()

Return the recursion count.

Return type

int

free()

Free mutex resources.

Return type

None

Condition variable

class `mpi4py.util.sync.Condition`

Condition variable.

A condition variable allows one or more MPI processes to wait until they are notified by another processes.

The condition variable interface is close to that of `threading.Condition`, allowing the use of either recursive or non-recursive mutual exclusion. However, the condition variable should be used within a group of MPI processes, not threads.

This condition variable implementation uses a MPI-3 RMA-based scalable and fair circular queue algorithm to track the set of waiting processes.

__init__(*mutex=None, *, recursive=True, comm=COMM_SELF, info=INFO_NULL*)

Initialize condition variable.

Parameters

- **mutex** (*Mutex* / *None*) – Mutual exclusion object.
- **recursive** (*bool*) – Whether to allow recursive acquisition.
- **comm** (*Intracomm*) – Intracommunicator context.
- **info** (*Info*) – Info object for RMA context creation.

Return type

None

__enter__()

Acquire the underlying mutex.

Return type

Self

__exit__(**exc*)

Release the underlying mutex.

Parameters

exc (*object*)

Return type

None

acquire(*blocking=True*)

Acquire the underlying mutex.

Parameters

blocking (*bool*)

Return type

bool

release()

Release the underlying mutex.

Return type

None

locked()

Return whether the underlying mutex is held.

Return type

bool

wait()

Wait until notified by another process.

Returns

Always `True`.

Return type

Literal[`True`]

wait_for(*predicate*)

Wait until a predicate evaluates to `True`.

Parameters

predicate (*Callable*[[`T`], `T`]) – callable returning a boolean.

Returns

The result of predicate once it evaluates to `True`.

Return type

`T`

notify(*n=1*)

Wake up one or more processes waiting on this condition.

Parameters

n (*int*) – Maximum number of processes to wake up.

Returns

The actual number of processes woken up.

Return type

`int`

notify_all()

Wake up all processes waiting on this condition.

Returns

The actual number of processes woken up.

Return type

`int`

free()

Free condition resources.

Return type

None

Semaphore object

class `mpi4py.util.sync.Semaphore`

Semaphore object.

A semaphore object manages an internal counter which is decremented by each `acquire()` call and incremented by each `release()` call. The internal counter never reaches a value below zero; when `acquire()` finds that it is zero, it blocks and waits until some other process calls `release()`.

The semaphore interface is close to that of `threading.Semaphore` and `threading.BoundedSemaphore`, allowing the use of either bounded (default) or unbounded semaphores. With a bounded semaphore, the internal counter never exceeds its initial value; otherwise `release()` raises `ValueError`.

This semaphore implementation uses a global `Counter` and a `Condition` variable to handle waiting and notification.

`__init__(value=1, *, bounded=True, comm=COMM_SELF, info=INFO_NULL)`

Initialize semaphore object.

Parameters

- **value** (*int*) – Initial value for internal counter.
- **bounded** (*bool*) – Bound internal counter to initial value.
- **comm** (*Intracomm*) – Intracommunicator context.
- **info** (*Info*) – Info object for RMA context creation.

Return type

None

`__enter__()`

Acquire semaphore.

Return type

Self

`__exit__(*exc)`

Release semaphore.

Parameters

exc (*object*)

Return type

None

`acquire(blocking=True)`

Acquire semaphore, decrementing the internal counter by one.

Parameters

blocking (*bool*) – If `True`, block until the semaphore is acquired.

Returns

`True` if the semaphore is acquired, `False` otherwise.

Return type

bool

`release(n=1)`

Release semaphore, incrementing the internal counter by one or more.

Parameters

n (*int*) – Increment for the internal counter.

Return type

None

free()

Free semaphore resources.

Return type

None

Examples

Listing 5: test-sync-1.py

```
1 from mpi4py import MPI
2 from mpi4py.util.sync import Counter, Sequential
3
4 comm = MPI.COMM_WORLD
5
6 counter = Counter(comm)
7 with Sequential(comm):
8     value = next(counter)
9 counter.free()
10
11 assert comm.rank == value
```

Listing 6: test-sync-2.py

```
1 from mpi4py import MPI
2 from mpi4py.util.sync import Counter, Mutex
3
4 comm = MPI.COMM_WORLD
5
6 mutex = Mutex(comm)
7 counter = Counter(comm)
8 with mutex:
9     value = next(counter)
10 counter.free()
11 mutex.free()
12
13 assert (
14     list(range(comm.size)) ==
15     sorted(comm.allgather(value))
16 )
```

9 mpi4py.run

Added in version 3.0.0.

At import time, *mpi4py* initializes the MPI execution environment calling `MPI_Init_thread()` and installs an exit hook to automatically call `MPI_Finalize()` just before the Python process terminates. Additionally, *mpi4py* overrides the default `ERRORS_ARE_FATAL` error handler in favor of `ERRORS_RETURN`, which allows translating MPI errors in Python exceptions. These departures from standard MPI behavior may be controversial, but are quite convenient within the highly dynamic Python programming environment. Third-party code using *mpi4py* can just `from mpi4py import MPI` and perform MPI calls without the tedious initialization/finalization handling. MPI errors, once trans-

lated automatically to Python exceptions, can be dealt with the common `try...except...finally` clauses; unhandled MPI exceptions will print a traceback which helps in locating problems in source code.

Unfortunately, the interplay of automatic MPI finalization and unhandled exceptions may lead to deadlocks. In unattended runs, these deadlocks will drain the battery of your laptop, or burn precious allocation hours in your supercomputing facility.

9.1 Exceptions and deadlocks

Consider the following snippet of Python code. Assume this code is stored in a standard Python script file and run with `mpiexec` in two or more processes.

Listing 7: deadlock.py

```
1 from mpi4py import MPI
2 assert MPI.COMM_WORLD.Get_size() > 1
3 rank = MPI.COMM_WORLD.Get_rank()
4 if rank == 0:
5     1/0
6     MPI.COMM_WORLD.send(None, dest=1, tag=42)
7 elif rank == 1:
8     MPI.COMM_WORLD.recv(source=0, tag=42)
```

Process 0 raises `ZeroDivisionError` exception before performing a send call to process 1. As the exception is not handled, the Python interpreter running in process 0 will proceed to exit with non-zero status. However, as `mpi4py` installed a finalizer hook to call `MPI_Finalize()` before exit, process 0 will block waiting for other processes to also enter the `MPI_Finalize()` call. Meanwhile, process 1 will block waiting for a message to arrive from process 0, thus never reaching to `MPI_Finalize()`. The whole MPI execution environment is irremediably in a deadlock state.

To alleviate this issue, `mpi4py` offers a simple, alternative command line execution mechanism based on using the `-m` flag and implemented with the `runpy` module. To use this features, Python code should be run passing `-m mpi4py` in the command line invoking the Python interpreter. In case of unhandled exceptions, the finalizer hook will call `MPI_Abort()` on the `MPI_COMM_WORLD` communicator, thus effectively aborting the MPI execution environment.

Warning

When a process is forced to abort, resources (e.g. open files) are not cleaned-up and any registered finalizers (either with the `atexit` module, the Python C/API function `Py_AtExit()`, or even the C standard library function `atexit()`) will not be executed. Thus, aborting execution is an extremely impolite way of ensuring process termination. However, MPI provides no other mechanism to recover from a deadlock state.

9.2 Command line

The use of `-m mpi4py` to execute Python code on the command line resembles that of the Python interpreter.

- `mpiexec -n numprocs python -m mpi4py pyfile [arg] ...`
- `mpiexec -n numprocs python -m mpi4py -m mod [arg] ...`
- `mpiexec -n numprocs python -m mpi4py -c cmd [arg] ...`
- `mpiexec -n numprocs python -m mpi4py - [arg] ...`

<pyfile>

Execute the Python code contained in *pyfile*, which must be a filesystem path referring to either a Python file, a directory containing a `__main__.py` file, or a zipfile containing a `__main__.py` file.

- m** <mod>
Search `sys.path` for the named module *mod* and execute its contents.
- c** <cmd>
Execute the Python code in the *cmd* string command.
- Read commands from standard input (`sys.stdin`).

 **See also**

Command line

Documentation on Python command line interface.

10 mpi4py.bench

Added in version 3.0.0.

11 Reference

mpi4py.MPI

Message Passing Interface.

11.1 mpi4py.MPI

Message Passing Interface.

Classes

<i>BottomType</i>	Type of <i>BOTTOM</i> .
<i>BufferAutomaticType</i>	Type of <i>BUFFER_AUTOMATIC</i> .
<i>Cartcomm</i>	Cartesian topology intracommunicator.
<i>Comm</i>	Communication context.
<i>Datatype</i>	Datatype object.
<i>Distgraphcomm</i>	Distributed graph topology intracommunicator.
<i>Errhandler</i>	Error handler.
<i>File</i>	File I/O context.
<i>Graphcomm</i>	General graph topology intracommunicator.
<i>Grequest</i>	Generalized request handler.
<i>Group</i>	Group of processes.
<i>InPlaceType</i>	Type of <i>IN_PLACE</i> .
<i>Info</i>	Info object.
<i>Intercomm</i>	Intercommunicator.
<i>Intracomm</i>	Intracommunicator.
<i>Message</i>	Matched message.
<i>Op</i>	Reduction operation.
<i>Pickle</i>	Pickle/unpickle Python objects.
<i>Prequest</i>	Persistent request handler.
<i>Request</i>	Request handler.

continues on next page

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<i>Session</i>	Session context.
<i>Status</i>	Status object.
<i>Topocomm</i>	Topology intracommunicator.
<i>Win</i>	Remote memory access context.
<i>buffer</i>	Buffer.
<i>memory</i>	alias of <i>buffer</i>

mpi4py.MPI.BottomType

class mpi4py.MPI.BottomType

Bases: object

Type of *BOTTOM*.

static `__new__(cls)`

Return type

Self

mpi4py.MPI.BufferAutomaticType

class mpi4py.MPI.BufferAutomaticType

Bases: object

Type of *BUFFER_AUTOMATIC*.

static `__new__(cls)`

Return type

Self

mpi4py.MPI.Cartcomm

class mpi4py.MPI.Cartcomm

Bases: *Topocomm*

Cartesian topology intracommunicator.

static `__new__(cls, comm=None)`

Parameters

`comm` (*Cartcomm* | *None*)

Return type

Self

Methods Summary

<i>Get_cart_rank</i> (coords)	Translate logical coordinates to ranks.
<i>Get_coords</i> (rank)	Translate ranks to logical coordinates.
<i>Get_dim</i> ()	Return number of dimensions.
<i>Get_topo</i> ()	Return information on the cartesian topology.
<i>Shift</i> (direction, disp)	Return a process ranks for data shifting with <i>Sendrecv</i> .
<i>Sub</i> (remain_dims)	Return a lower-dimensional Cartesian topology.

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Attributes Summary

<i>coords</i>	Coordinates.
<i>dim</i>	Number of dimensions.
<i>dims</i>	Dimensions.
<i>ndim</i>	Number of dimensions.
<i>periods</i>	Periodicity.
<i>topo</i>	Topology information.

Methods Documentation

Get_cart_rank(*coords*)

Translate logical coordinates to ranks.

Parameters

coords (*Sequence[int]*)

Return type

int

Get_coords(*rank*)

Translate ranks to logical coordinates.

Parameters

rank (*int*)

Return type

list[int]

Get_dim()

Return number of dimensions.

Return type

int

Get_topo()

Return information on the cartesian topology.

Return type

tuple[list[int], list[int], list[int]]

Shift(*direction*, *disp*)

Return a process ranks for data shifting with *Sendrecv*.

Parameters

- **direction** (*int*)
- **disp** (*int*)

Return type

tuple[int, int]

Sub(*remain_dims*)

Return a lower-dimensional Cartesian topology.

Parameters**remain_dims** (*Sequence* [*bool*])**Return type***Cartcomm***Attributes Documentation****coords**

Coordinates.

dim

Number of dimensions.

dims

Dimensions.

ndim

Number of dimensions.

periods

Periodicity.

topo

Topology information.

mpi4py.MPI.Comm**class** `mpi4py.MPI.Comm`Bases: `object`

Communication context.

static `__new__(cls, comm=None)`**Parameters****comm** (`Comm` | `None`)**Return type***Self***Methods Summary**

<i>Abort</i> ([errorcode])	Terminate the MPI execution environment.
<i>Ack_failed</i> ([num_to_ack])	Acknowledge failures on a communicator.
<i>Agree</i> (flag)	Blocking agreement.
<i>Allgather</i> (sendbuf, recvbuf)	Gather to All.
<i>Allgather_init</i> (sendbuf, recvbuf[, info])	Persistent Gather to All.
<i>Allgatherv</i> (sendbuf, recvbuf)	Gather to All Vector.
<i>Allgatherv_init</i> (sendbuf, recvbuf[, info])	Persistent Gather to All Vector.
<i>Allreduce</i> (sendbuf, recvbuf[, op])	Reduce to All.
<i>Allreduce_init</i> (sendbuf, recvbuf[, op, info])	Persistent Reduce to All.
<i>Alltoall</i> (sendbuf, recvbuf)	All to All Scatter/Gather.
<i>Alltoall_init</i> (sendbuf, recvbuf[, info])	Persistent All to All Scatter/Gather.
<i>Alltoallv</i> (sendbuf, recvbuf)	All to All Scatter/Gather Vector.
<i>Alltoallv_init</i> (sendbuf, recvbuf[, info])	Persistent All to All Scatter/Gather Vector.

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<i>Alltoallw</i> (sendbuf, recvbuf)	All to All Scatter/Gather General.
<i>Alltoallw_init</i> (sendbuf, recvbuf[, info])	Persistent All to All Scatter/Gather General.
<i>Attach_buffer</i> (buf)	Attach a user-provided buffer for sending in buffered mode.
<i>Barrier</i> ()	Barrier synchronization.
<i>Barrier_init</i> ([info])	Persistent Barrier.
<i>Bcast</i> (buf[, root])	Broadcast data from one process to all other processes.
<i>Bcast_init</i> (buf[, root, info])	Persistent Broadcast.
<i>Bsend</i> (buf, dest[, tag])	Blocking send in buffered mode.
<i>Bsend_init</i> (buf, dest[, tag])	Persistent request for a send in buffered mode.
<i>Call_errhandler</i> (errorcode)	Call the error handler installed on a communicator.
<i>Clone</i> ()	Clone an existing communicator.
<i>Compare</i> (comm)	Compare two communicators.
<i>Create</i> (group)	Create communicator from group.
<i>Create_errhandler</i> (errhandler_fn)	Create a new error handler for communicators.
<i>Create_keyval</i> ([copy_fn, delete_fn, nopython])	Create a new attribute key for communicators.
<i>Delete_attr</i> (keyval)	Delete attribute value associated with a key.
<i>Detach_buffer</i> ()	Remove an existing attached buffer.
<i>Disconnect</i> ()	Disconnect from a communicator.
<i>Dup</i> ([info])	Duplicate a communicator.
<i>Dup_with_info</i> (info)	Duplicate a communicator with hints.
<i>Flush_buffer</i> ()	Block until all buffered messages have been transmitted.
<i>Free</i> ()	Free a communicator.
<i>Free_keyval</i> (keyval)	Free an attribute key for communicators.
<i>Gather</i> (sendbuf, recvbuf[, root])	Gather data to one process from all other processes.
<i>Gather_init</i> (sendbuf, recvbuf[, root, info])	Persistent Gather.
<i>Gatherv</i> (sendbuf, recvbuf[, root])	Gather Vector.
<i>Gatherv_init</i> (sendbuf, recvbuf[, root, info])	Persistent Gather Vector.
<i>Get_attr</i> (keyval)	Retrieve attribute value by key.
<i>Get_errhandler</i> ()	Get the error handler for a communicator.
<i>Get_failed</i> ()	Extract the group of failed processes.
<i>Get_group</i> ()	Access the group associated with a communicator.
<i>Get_info</i> ()	Return the current hints for a communicator.
<i>Get_name</i> ()	Get the print name for this communicator.
<i>Get_parent</i> ()	Return the parent intercommunicator for this process.
<i>Get_rank</i> ()	Return the rank of this process in a communicator.
<i>Get_size</i> ()	Return the number of processes in a communicator.
<i>Get_topology</i> ()	Return the type of topology (if any) associated with a communicator.
<i>Iagree</i> (flag)	Nonblocking agreement.
<i>Iallgather</i> (sendbuf, recvbuf)	Nonblocking Gather to All.
<i>Iallgatherv</i> (sendbuf, recvbuf)	Nonblocking Gather to All Vector.
<i>Iallreduce</i> (sendbuf, recvbuf[, op])	Nonblocking Reduce to All.
<i>Ialltoall</i> (sendbuf, recvbuf)	Nonblocking All to All Scatter/Gather.
<i>Ialltoallv</i> (sendbuf, recvbuf)	Nonblocking All to All Scatter/Gather Vector.
<i>Ialltoallw</i> (sendbuf, recvbuf)	Nonblocking All to All Scatter/Gather General.
<i>Ibarrier</i> ()	Nonblocking Barrier.
<i>Ibcast</i> (buf[, root])	Nonblocking Broadcast.
<i>Ibsend</i> (buf, dest[, tag])	Nonblocking send in buffered mode.
<i>Idup</i> ([info])	Nonblocking duplicate a communicator.

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<i>Idup_with_info</i> (info)	Nonblocking duplicate a communicator with hints.
<i>Iflush_buffer</i> ()	Nonblocking flush for buffered messages.
<i>Igather</i> (sendbuf, recvbuf[, root])	Nonblocking Gather.
<i>Igatherv</i> (sendbuf, recvbuf[, root])	Nonblocking Gather Vector.
<i>Improbe</i> ([source, tag, status])	Nonblocking test for a matched message.
<i>Iprobe</i> ([source, tag, status])	Nonblocking test for a message.
<i>Irecv</i> (buf[, source, tag])	Nonblocking receive.
<i>Ireduce</i> (sendbuf, recvbuf[, op, root])	Nonblocking Reduce to Root.
<i>Ireduce_scatter</i> (sendbuf, recvbuf[, ...])	Nonblocking Reduce-Scatter (vector version).
<i>Ireduce_scatter_block</i> (sendbuf, recvbuf[, op])	Nonblocking Reduce-Scatter Block (regular, non-vector version).
<i>Irsend</i> (buf, dest[, tag])	Nonblocking send in ready mode.
<i>Is_inter</i> ()	Return whether the communicator is an intercommunicator.
<i>Is_intra</i> ()	Return whether the communicator is an intracommunicator.
<i>Is_revoked</i> ()	Indicate whether the communicator has been revoked.
<i>Iscatter</i> (sendbuf, recvbuf[, root])	Nonblocking Scatter.
<i>Iscatterv</i> (sendbuf, recvbuf[, root])	Nonblocking Scatter Vector.
<i>Isend</i> (buf, dest[, tag])	Nonblocking send.
<i>Isendrecv</i> (sendbuf, dest[, sendtag, recvbuf, ...])	Nonblocking send and receive.
<i>Isendrecv_replace</i> (buf, dest[, sendtag, ...])	Send and receive a message.
<i>Ishrink</i> ()	Nonblocking shrink a communicator to remove all failed processes.
<i>Issend</i> (buf, dest[, tag])	Nonblocking send in synchronous mode.
<i>Join</i> (fd)	Interconnect two processes connected by a socket.
<i>Mprobe</i> ([source, tag, status])	Blocking test for a matched message.
<i>Precv_init</i> (buf, partitions[, source, tag, info])	Create request for a partitioned recv operation.
<i>Probe</i> ([source, tag, status])	Blocking test for a message.
<i>Psend_init</i> (buf, partitions, dest[, tag, info])	Create request for a partitioned send operation.
<i>Recv</i> (buf[, source, tag, status])	Blocking receive.
<i>Recv_init</i> (buf[, source, tag])	Create a persistent request for a receive.
<i>Reduce</i> (sendbuf, recvbuf[, op, root])	Reduce to Root.
<i>Reduce_init</i> (sendbuf, recvbuf[, op, root, info])	Persistent Reduce to Root.
<i>Reduce_scatter</i> (sendbuf, recvbuf[, ...])	Reduce-Scatter (vector version).
<i>Reduce_scatter_block</i> (sendbuf, recvbuf[, op])	Reduce-Scatter Block (regular, non-vector version).
<i>Reduce_scatter_block_init</i> (sendbuf, recvbuf)	Persistent Reduce-Scatter Block (regular, non-vector version).
<i>Reduce_scatter_init</i> (sendbuf, recvbuf[, ...])	Persistent Reduce-Scatter (vector version).
<i>Revoke</i> ()	Revoke a communicator.
<i>Rsend</i> (buf, dest[, tag])	Blocking send in ready mode.
<i>Rsend_init</i> (buf, dest[, tag])	Persistent request for a send in ready mode.
<i>Scatter</i> (sendbuf, recvbuf[, root])	Scatter data from one process to all other processes.
<i>Scatter_init</i> (sendbuf, recvbuf[, root, info])	Persistent Scatter.
<i>Scatterv</i> (sendbuf, recvbuf[, root])	Scatter Vector.
<i>Scatterv_init</i> (sendbuf, recvbuf[, root, info])	Persistent Scatter Vector.
<i>Send</i> (buf, dest[, tag])	Blocking send.
<i>Send_init</i> (buf, dest[, tag])	Create a persistent request for a standard send.
<i>Sendrecv</i> (sendbuf, dest[, sendtag, recvbuf, ...])	Send and receive a message.
<i>Sendrecv_replace</i> (buf, dest[, sendtag, ...])	Send and receive a message.
<i>Set_attr</i> (keyval, attrval)	Store attribute value associated with a key.

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<i>Set_errhandler</i> (errhandler)	Set the error handler for a communicator.
<i>Set_info</i> (info)	Set new values for the hints associated with a communicator.
<i>Set_name</i> (name)	Set the print name for this communicator.
<i>Shrink</i> ()	Shrink a communicator to remove all failed processes.
<i>Split</i> ([color, key])	Split communicator by color and key.
<i>Split_type</i> (split_type[, key, info])	Split communicator by split type.
<i>Ssend</i> (buf, dest[, tag])	Blocking send in synchronous mode.
<i>Ssend_init</i> (buf, dest[, tag])	Persistent request for a send in synchronous mode.
<i>allgather</i> (sendobj)	Gather to All.
<i>allreduce</i> (sendobj[, op])	Reduce to All.
<i>alltoall</i> (sendobj)	All to All Scatter/Gather.
<i>barrier</i> ()	Barrier synchronization.
<i>bcast</i> (obj[, root])	Broadcast.
<i>bsend</i> (obj, dest[, tag])	Send in buffered mode.
<i>f2py</i> (arg)	
<i>free</i> ()	Call <i>Free</i> if not null or predefined.
<i>fromhandle</i> (handle)	Create object from MPI handle.
<i>fromint</i> (arg, /)	Translate integer handle to object.
<i>gather</i> (sendobj[, root])	Gather.
<i>ibsend</i> (obj, dest[, tag])	Nonblocking send in buffered mode.
<i>improbe</i> ([source, tag, status])	Nonblocking test for a matched message.
<i>iprobe</i> ([source, tag, status])	Nonblocking test for a message.
<i>irecv</i> ([buf, source, tag])	Nonblocking receive.
<i>isend</i> (obj, dest[, tag])	Nonblocking send.
<i>issend</i> (obj, dest[, tag])	Nonblocking send in synchronous mode.
<i>mprobe</i> ([source, tag, status])	Blocking test for a matched message.
<i>probe</i> ([source, tag, status])	Blocking test for a message.
<i>py2f</i> ()	
<i>recv</i> ([buf, source, tag, status])	Receive.
<i>reduce</i> (sendobj[, op, root])	Reduce to Root.
<i>scatter</i> (sendobj[, root])	Scatter.
<i>send</i> (obj, dest[, tag])	Send in standard mode.
<i>sendrecv</i> (sendobj, dest[, sendtag, recvbuf, ...])	Send and Receive.
<i>ssend</i> (obj, dest[, tag])	Send in synchronous mode.
<i>toint</i> ()	Translate object to integer handle.

Attributes Summary

<i>group</i>	Group.
<i>handle</i>	MPI handle.
<i>info</i>	Info hints.
<i>is_inter</i>	Is intercommunicator.
<i>is_intra</i>	Is intracommunicator.
<i>is_topo</i>	Is a topology.
<i>name</i>	Print name.
<i>rank</i>	Rank of this process.
<i>size</i>	Number of processes.

continues on next page

<i>topology</i>	Topology type.
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Methods Documentation

Abort(*errorcode=0*)

Terminate the MPI execution environment.

Warning

The invocation of this method prevents the execution of various Python exit and cleanup mechanisms. Use this method as a last resort to prevent parallel deadlocks in case of unrecoverable errors.

Parameters

errorcode (*int*)

Return type

NoReturn

Ack_failed(*num_to_ack=None*)

Acknowledge failures on a communicator.

Parameters

num_to_ack (*int* | *None*)

Return type

int

Agree(*flag*)

Blocking agreement.

Parameters

flag (*int*)

Return type

int

Allgather(*sendbuf, recvbuf*)

Gather to All.

Gather data from all processes and broadcast the combined data to all other processes.

Parameters

- **sendbuf** (*BufSpec* | *InPlace*)
- **recvbuf** (*BufSpecB*)

Return type

None

Allgather_init(*sendbuf, recvbuf, info=INFO_NULL*)

Persistent Gather to All.

Parameters

- **sendbuf** (*BufSpec* | *InPlace*)
- **recvbuf** (*BufSpecB*)

- **info** (*Info*)

Return type

Prequest

Allgatherv(*sendbuf, recvbuf*)

Gather to All Vector.

Gather data from all processes and send it to all other processes providing different amounts of data and displacements.

Parameters

- **sendbuf** (*BufSpec* / *InPlace*)
- **recvbuf** (*BufSpecV*)

Return type

None

Allgatherv_init(*sendbuf, recvbuf, info=INFO_NULL*)

Persistent Gather to All Vector.

Parameters

- **sendbuf** (*BufSpec* / *InPlace*)
- **recvbuf** (*BufSpecV*)
- **info** (*Info*)

Return type

Prequest

Allreduce(*sendbuf, recvbuf, op=SUM*)

Reduce to All.

Parameters

- **sendbuf** (*BufSpec* / *InPlace*)
- **recvbuf** (*BufSpec*)
- **op** (*Op*)

Return type

None

Allreduce_init(*sendbuf, recvbuf, op=SUM, info=INFO_NULL*)

Persistent Reduce to All.

Parameters

- **sendbuf** (*BufSpec* / *InPlace*)
- **recvbuf** (*BufSpec*)
- **op** (*Op*)
- **info** (*Info*)

Return type

Prequest

Alltoall(*sendbuf*, *recvbuf*)

All to All Scatter/Gather.

Send data to all processes and recv data from all processes.

Parameters

- **sendbuf** (BufSpecB / InPlace)
- **recvbuf** (BufSpecB)

Return type

None

Alltoall_init(*sendbuf*, *recvbuf*, *info=INFO_NULL*)

Persistent All to All Scatter/Gather.

Parameters

- **sendbuf** (BufSpecB / InPlace)
- **recvbuf** (BufSpecB)
- **info** (Info)

Return type

Prequest

Alltoallv(*sendbuf*, *recvbuf*)

All to All Scatter/Gather Vector.

Send data to all processes and recv data from all processes providing different amounts of data and displacements.

Parameters

- **sendbuf** (BufSpecV / InPlace)
- **recvbuf** (BufSpecV)

Return type

None

Alltoallv_init(*sendbuf*, *recvbuf*, *info=INFO_NULL*)

Persistent All to All Scatter/Gather Vector.

Parameters

- **sendbuf** (BufSpecV / InPlace)
- **recvbuf** (BufSpecV)
- **info** (Info)

Return type

Prequest

Alltoallw(*sendbuf*, *recvbuf*)

All to All Scatter/Gather General.

Send/recv data to/from all processes allowing the specification of different counts, displacements, and datatypes for each dest/source.

Parameters

- **sendbuf** (BufSpecW / InPlace)

- **recvbuf** (BufSpecW)

Return type

None

Alltoallw_init(*sendbuf*, *recvbuf*, *info=INFO_NULL*)

Persistent All to All Scatter/Gather General.

Parameters

- **sendbuf** (BufSpecW / InPlace)
- **recvbuf** (BufSpecW)
- **info** (Info)

Return type

Prequest

Attach_buffer(*buf*)

Attach a user-provided buffer for sending in buffered mode.

Parameters

buf (Buffer / None)

Return type

None

Barrier()

Barrier synchronization.

Return type

None

Barrier_init(*info=INFO_NULL*)

Persistent Barrier.

Parameters

info (Info)

Return type

Prequest

Bcast(*buf*, *root=0*)

Broadcast data from one process to all other processes.

Parameters

- **buf** (BufSpec)
- **root** (*int*)

Return type

None

Bcast_init(*buf*, *root=0*, *info=INFO_NULL*)

Persistent Broadcast.

Parameters

- **buf** (BufSpec)
- **root** (*int*)
- **info** (Info)

Return type

Prequest

Bsend(*buf*, *dest*, *tag=0*)

Blocking send in buffered mode.

Parameters

- **buf** (BufSpec)
- **dest** (*int*)
- **tag** (*int*)

Return type

None

Bsend_init(*buf*, *dest*, *tag=0*)

Persistent request for a send in buffered mode.

Parameters

- **buf** (BufSpec)
- **dest** (*int*)
- **tag** (*int*)

Return type

Request

Call_errhandler(*errorcode*)

Call the error handler installed on a communicator.

Parameters

errorcode (*int*)

Return type

None

Clone()

Clone an existing communicator.

Return type

Self

Compare(*comm*)

Compare two communicators.

Parameters

comm (Comm)

Return type

int

Create(*group*)

Create communicator from group.

Parameters

group (Group)

Return type

Comm

classmethod `Create_errhandler`(*errhandler_fn*)

Create a new error handler for communicators.

Parameters

errhandler_fn (*Callable*[[*Comm*, *int*], *None*])

Return type

Errhandler

classmethod `Create_keyval`(*copy_fn=None*, *delete_fn=None*, *nopython=False*)

Create a new attribute key for communicators.

Parameters

- **copy_fn** (*Callable*[[*Comm*, *int*, *Any*], *Any*] | *None*)
- **delete_fn** (*Callable*[[*Comm*, *int*, *Any*], *None*] | *None*)
- **nopython** (*bool*)

Return type

int

Delete_attr(*keyval*)

Delete attribute value associated with a key.

Parameters

keyval (*int*)

Return type

None

Detach_buffer()

Remove an existing attached buffer.

Return type

Buffer | *None*

Disconnect()

Disconnect from a communicator.

Return type

None

Dup(*info=None*)

Duplicate a communicator.

Parameters

info (*Info* | *None*)

Return type

Self

Dup_with_info(*info*)

Duplicate a communicator with hints.

Parameters

info (*Info*)

Return type

Self

Flush_buffer()

Block until all buffered messages have been transmitted.

Return type

None

Free()

Free a communicator.

Return type

None

classmethod Free_keyval(keyval)

Free an attribute key for communicators.

Parameters

keyval (*int*)

Return type

int

Gather(sendbuf, recvbuf, root=0)

Gather data to one process from all other processes.

Parameters

• **sendbuf** (BufSpec / InPlace)

• **recvbuf** (BufSpecB / None)

• **root** (*int*)

Return type

None

Gather_init(sendbuf, recvbuf, root=0, info=INFO_NULL)

Persistent Gather.

Parameters

• **sendbuf** (BufSpec / InPlace)

• **recvbuf** (BufSpecB / None)

• **root** (*int*)

• **info** (Info)

Return type

Prequest

Gatherv(sendbuf, recvbuf, root=0)

Gather Vector.

Gather data to one process from all other processes providing different amounts of data and displacements.

Parameters

• **sendbuf** (BufSpec / InPlace)

• **recvbuf** (BufSpecV / None)

• **root** (*int*)

Return type

None

Gatherv_init(*sendbuf*, *recvbuf*, *root=0*, *info=INFO_NULL*)

Persistent Gather Vector.

Parameters

- **sendbuf** (BufSpec / InPlace)
- **recvbuf** (BufSpecV / None)
- **root** (*int*)
- **info** (Info)

Return type

Prequest

Get_attr(*keyval*)

Retrieve attribute value by key.

Parameters

keyval (*int*)

Return type

int | *Any* | *None*

Get_errhandler()

Get the error handler for a communicator.

Return type

Errhandler

Get_failed()

Extract the group of failed processes.

Return type

Group

Get_group()

Access the group associated with a communicator.

Return type

Group

Get_info()

Return the current hints for a communicator.

Return type

Info

Get_name()

Get the print name for this communicator.

Return type

str

classmethod Get_parent()

Return the parent intercommunicator for this process.

Return type

Intercomm

Get_rank()

Return the rank of this process in a communicator.

Return type

int

Get_size()

Return the number of processes in a communicator.

Return type

int

Get_topology()

Return the type of topology (if any) associated with a communicator.

Return type

int

Iagree(flag)

Nonblocking agreement.

Parameters

flag (Buffer)

Return type

Request

Iallgather(sendbuf, recvbuf)

Nonblocking Gather to All.

Parameters

- **sendbuf** (BufSpec / InPlace)
- **recvbuf** (BufSpecB)

Return type

Request

Iallgatherv(sendbuf, recvbuf)

Nonblocking Gather to All Vector.

Parameters

- **sendbuf** (BufSpec / InPlace)
- **recvbuf** (BufSpecV)

Return type

Request

Iallreduce(sendbuf, recvbuf, op=SUM)

Nonblocking Reduce to All.

Parameters

- **sendbuf** (BufSpec / InPlace)
- **recvbuf** (BufSpec)
- **op** (Op)

Return type

Request

Ialltoall(*sendbuf*, *recvbuf*)

Nonblocking All to All Scatter/Gather.

Parameters

- **sendbuf** (BufSpecB / InPlace)
- **recvbuf** (BufSpecB)

Return type

Request

Ialltoallv(*sendbuf*, *recvbuf*)

Nonblocking All to All Scatter/Gather Vector.

Parameters

- **sendbuf** (BufSpecV / InPlace)
- **recvbuf** (BufSpecV)

Return type

Request

Ialltoallw(*sendbuf*, *recvbuf*)

Nonblocking All to All Scatter/Gather General.

Parameters

- **sendbuf** (BufSpecW / InPlace)
- **recvbuf** (BufSpecW)

Return type

Request

Ibarrier()

Nonblocking Barrier.

Return type

Request

Ibcast(*buf*, *root=0*)

Nonblocking Broadcast.

Parameters

- **buf** (BufSpec)
- **root** (*int*)

Return type

Request

IbSEND(*buf*, *dest*, *tag=0*)

Nonblocking send in buffered mode.

Parameters

- **buf** (BufSpec)
- **dest** (*int*)
- **tag** (*int*)

Return type*Request***Idup**(*info=None*)

Nonblocking duplicate a communicator.

Parameters**info** (*Info* / *None*)**Return type***tuple*[*Self*, *Request*]**Idup_with_info**(*info*)

Nonblocking duplicate a communicator with hints.

Parameters**info** (*Info*)**Return type***tuple*[*Self*, *Request*]**Iflush_buffer**()

Nonblocking flush for buffered messages.

Return type*Request***Igather**(*sendbuf*, *recvbuf*, *root=0*)

Nonblocking Gather.

Parameters

- **sendbuf** (*BufSpec* / *InPlace*)
- **recvbuf** (*BufSpecB* / *None*)
- **root** (*int*)

Return type*Request***Igatherv**(*sendbuf*, *recvbuf*, *root=0*)

Nonblocking Gather Vector.

Parameters

- **sendbuf** (*BufSpec* / *InPlace*)
- **recvbuf** (*BufSpecV* / *None*)
- **root** (*int*)

Return type*Request***Improbe**(*source=ANY_SOURCE*, *tag=ANY_TAG*, *status=None*)

Nonblocking test for a matched message.

Parameters

- **source** (*int*)
- **tag** (*int*)
- **status** (*Status* / *None*)

Return type

Message | None

Iprobe(*source=ANY_SOURCE, tag=ANY_TAG, status=None*)

Nonblocking test for a message.

Parameters

- **source** (*int*)
- **tag** (*int*)
- **status** (*Status | None*)

Return type

bool

Irecv(*buf, source=ANY_SOURCE, tag=ANY_TAG*)

Nonblocking receive.

Parameters

- **buf** (*BufSpec*)
- **source** (*int*)
- **tag** (*int*)

Return type

Request

Ireduce(*sendbuf, recvbuf, op=SUM, root=0*)

Nonblocking Reduce to Root.

Parameters

- **sendbuf** (*BufSpec | InPlace*)
- **recvbuf** (*BufSpec | None*)
- **op** (*Op*)
- **root** (*int*)

Return type

Request

Ireduce_scatter(*sendbuf, recvbuf, recvcnts=None, op=SUM*)

Nonblocking Reduce-Scatter (vector version).

Parameters

- **sendbuf** (*BufSpec | InPlace*)
- **recvbuf** (*BufSpec*)
- **recvcnts** (*Sequence[int] | None*)
- **op** (*Op*)

Return type

Request

Ireduce_scatter_block(*sendbuf*, *recvbuf*, *op*=SUM)

Nonblocking Reduce-Scatter Block (regular, non-vector version).

Parameters

- **sendbuf** (BufSpecB / InPlace)
- **recvbuf** (BufSpec / BufSpecB)
- **op** (Op)

Return type

Request

Irsend(*buf*, *dest*, *tag*=0)

Nonblocking send in ready mode.

Parameters

- **buf** (BufSpec)
- **dest** (*int*)
- **tag** (*int*)

Return type

Request

Is_inter()

Return whether the communicator is an intercommunicator.

Return type

bool

Is_intra()

Return whether the communicator is an intracommunicator.

Return type

bool

Is_revoked()

Indicate whether the communicator has been revoked.

Return type

bool

Iscatter(*sendbuf*, *recvbuf*, *root*=0)

Nonblocking Scatter.

Parameters

- **sendbuf** (BufSpecB / None)
- **recvbuf** (BufSpec / InPlace)
- **root** (*int*)

Return type

Request

Iscatterv(*sendbuf*, *recvbuf*, *root*=0)

Nonblocking Scatter Vector.

Parameters

- **sendbuf** (BufSpecV | None)
- **recvbuf** (BufSpec | InPlace)
- **root** (*int*)

Return type

Request

Isend(*buf, dest, tag=0*)

Nonblocking send.

Parameters

- **buf** (BufSpec)
- **dest** (*int*)
- **tag** (*int*)

Return type

Request

Isendrecv(*sendbuf, dest, sendtag=0, recvbuf=None, source=ANY_SOURCE, recvtag=ANY_TAG*)

Nonblocking send and receive.

Parameters

- **sendbuf** (BufSpec)
- **dest** (*int*)
- **sendtag** (*int*)
- **recvbuf** (BufSpec | None)
- **source** (*int*)
- **recvtag** (*int*)

Return type


Request

Isendrecv_replace(*buf, dest, sendtag=0, source=ANY_SOURCE, recvtag=ANY_TAG*)

Send and receive a message.

 **Note**

This function is guaranteed not to deadlock in situations where pairs of blocking sends and receives may deadlock.

 **Caution**

A common mistake when using this function is to mismatch the tags with the source and destination ranks, which can result in deadlock.

Parameters

- **buf** (BufSpec)
- **dest** (*int*)

- **sendtag** (*int*)
- **source** (*int*)
- **recvtag** (*int*)

Return type

Request

Ishrink()

Nonblocking shrink a communicator to remove all failed processes.

Return type

tuple[Comm, Request]

Issend(*buf, dest, tag=0*)

Nonblocking send in synchronous mode.

Parameters

- **buf** (BufSpec)
- **dest** (*int*)
- **tag** (*int*)

Return type

Request

classmethod Join(*fd*)

Interconnect two processes connected by a socket.

Parameters

fd (*int*)

Return type

Intercomm

Mprobe(*source=ANY_SOURCE, tag=ANY_TAG, status=None*)

Blocking test for a matched message.

Parameters

- **source** (*int*)
- **tag** (*int*)
- **status** (Status | None)

Return type

Message

Precv_init(*buf, partitions, source=ANY_SOURCE, tag=ANY_TAG, info=INFO_NULL*)

Create request for a partitioned recv operation.

Parameters

- **buf** (BufSpec)
- **partitions** (*int*)
- **source** (*int*)
- **tag** (*int*)
- **info** (Info)

Return type

Prequest

Probe(*source=ANY_SOURCE, tag=ANY_TAG, status=None*)

Blocking test for a message.

Note

This function blocks until the message arrives.

Parameters

- **source** (*int*)
- **tag** (*int*)
- **status** (*Status | None*)

Return type

Literal[True]

Psend_init(*buf, partitions, dest, tag=0, info=INFO_NULL*)

Create request for a partitioned send operation.

Parameters

- **buf** (*BufSpec*)
- **partitions** (*int*)
- **dest** (*int*)
- **tag** (*int*)
- **info** (*Info*)

Return type

Prequest

Recv(*buf, source=ANY_SOURCE, tag=ANY_TAG, status=None*)

Blocking receive.

Note

This function blocks until the message is received.

Parameters

- **buf** (*BufSpec*)
- **source** (*int*)
- **tag** (*int*)
- **status** (*Status | None*)

Return type

None

Recv_init(*buf*, *source=ANY_SOURCE*, *tag=ANY_TAG*)

Create a persistent request for a receive.

Parameters

- **buf** (BufSpec)
- **source** (*int*)
- **tag** (*int*)

Return type

Prequest

Reduce(*sendbuf*, *recvbuf*, *op=SUM*, *root=0*)

Reduce to Root.

Parameters

- **sendbuf** (BufSpec | InPlace)
- **recvbuf** (BufSpec | None)
- **op** (Op)
- **root** (*int*)

Return type

None

Reduce_init(*sendbuf*, *recvbuf*, *op=SUM*, *root=0*, *info=INFO_NULL*)

Persistent Reduce to Root.

Parameters

- **sendbuf** (BufSpec | InPlace)
- **recvbuf** (BufSpec | None)
- **op** (Op)
- **root** (*int*)
- **info** (Info)

Return type

Prequest

Reduce_scatter(*sendbuf*, *recvbuf*, *recvcounts=None*, *op=SUM*)

Reduce-Scatter (vector version).

Parameters

- **sendbuf** (BufSpec | InPlace)
- **recvbuf** (BufSpec)
- **recvcounts** (Sequence[*int*] | None)
- **op** (Op)

Return type

None

Reduce_scatter_block(*sendbuf*, *recvbuf*, *op=SUM*)

Reduce-Scatter Block (regular, non-vector version).

Parameters

- **sendbuf** (BufSpecB / InPlace)
- **recvbuf** (BufSpec / BufSpecB)
- **op** (Op)

Return type

None

Reduce_scatter_block_init(*sendbuf*, *recvbuf*, *op=SUM*, *info=INFO_NULL*)

Persistent Reduce-Scatter Block (regular, non-vector version).

Parameters

- **sendbuf** (BufSpecB / InPlace)
- **recvbuf** (BufSpec / BufSpecB)
- **op** (Op)
- **info** (Info)

Return type

Prequest

Reduce_scatter_init(*sendbuf*, *recvbuf*, *recvcounts=None*, *op=SUM*, *info=INFO_NULL*)

Persistent Reduce-Scatter (vector version).

Parameters

- **sendbuf** (BufSpec / InPlace)
- **recvbuf** (BufSpec)
- **recvcounts** (Sequence[*int*] / None)
- **op** (Op)
- **info** (Info)

Return type

Prequest

Revoke()

Revoke a communicator.

Return type

None

Rsend(*buf*, *dest*, *tag=0*)

Blocking send in ready mode.

Parameters

- **buf** (BufSpec)
- **dest** (*int*)
- **tag** (*int*)

Return type

None

Rsend_init(*buf, dest, tag=0*)

Persistent request for a send in ready mode.

Parameters

- **buf** (BufSpec)
- **dest** (*int*)
- **tag** (*int*)

Return type

Request

Scatter(*sendbuf, recvbuf, root=0*)

Scatter data from one process to all other processes.

Parameters

- **sendbuf** (BufSpecB | None)
- **recvbuf** (BufSpec | InPlace)
- **root** (*int*)

Return type

None

Scatter_init(*sendbuf, recvbuf, root=0, info=INFO_NULL*)

Persistent Scatter.

Parameters

- **sendbuf** (BufSpecB | None)
- **recvbuf** (BufSpec | InPlace)
- **root** (*int*)
- **info** (Info)

Return type

Prequest

Scatterv(*sendbuf, recvbuf, root=0*)

Scatter Vector.

Scatter data from one process to all other processes providing different amounts of data and displacements.

Parameters

- **sendbuf** (BufSpecV | None)
- **recvbuf** (BufSpec | InPlace)
- **root** (*int*)

Return type

None

Scatterv_init(*sendbuf, recvbuf, root=0, info=INFO_NULL*)

Persistent Scatter Vector.

Parameters

- **sendbuf** (BufSpecV | None)

- **recvbuf** (BufSpec / InPlace)
- **root** (*int*)
- **info** (Info)

Return type
Prequest

Send(*buf, dest, tag=0*)

Blocking send.

Note

This function may block until the message is received. Whether *Send* blocks or not depends on several factors and is implementation dependent.

Parameters

- **buf** (BufSpec)
- **dest** (*int*)
- **tag** (*int*)

Return type
None

Send_init(*buf, dest, tag=0*)

Create a persistent request for a standard send.

Parameters

- **buf** (BufSpec)
- **dest** (*int*)
- **tag** (*int*)

Return type
Prequest

Sendrecv(*sendbuf, dest, sendtag=0, recvbuf=None, source=ANY_SOURCE, recvtag=ANY_TAG, status=None*)

Send and receive a message.

Note

This function is guaranteed not to deadlock in situations where pairs of blocking sends and receives may deadlock.

Caution

A common mistake when using this function is to mismatch the tags with the source and destination ranks, which can result in deadlock.

Parameters

- **sendbuf** (BufSpec)
- **dest** (*int*)
- **sendtag** (*int*)
- **recvbuf** (BufSpec | None)
- **source** (*int*)
- **recvtag** (*int*)
- **status** (Status | None)

Return type

None

Sendrecv_replace(*buf, dest, sendtag=0, source=ANY_SOURCE, recvtag=ANY_TAG, status=None*)

Send and receive a message.

Note

This function is guaranteed not to deadlock in situations where pairs of blocking sends and receives may deadlock.

Caution

A common mistake when using this function is to mismatch the tags with the source and destination ranks, which can result in deadlock.

Parameters

- **buf** (BufSpec)
- **dest** (*int*)
- **sendtag** (*int*)
- **source** (*int*)
- **recvtag** (*int*)
- **status** (Status | None)

Return type

None

Set_attr(*keyval, attrval*)

Store attribute value associated with a key.

Parameters

- **keyval** (*int*)
- **attrval** (*Any*)

Return type

None

Set_errhandler(*errhandler*)

Set the error handler for a communicator.

Parameters

errhandler (*Errhandler*)

Return type

None

Set_info(*info*)

Set new values for the hints associated with a communicator.

Parameters

info (*Info*)

Return type

None

Set_name(*name*)

Set the print name for this communicator.

Parameters

name (*str*)

Return type

None

Shrink()

Shrink a communicator to remove all failed processes.

Return type

Comm

Split(*color=0, key=0*)

Split communicator by color and key.

Parameters

- **color** (*int*)
- **key** (*int*)

Return type

Comm

Split_type(*split_type, key=0, info=INFO_NULL*)

Split communicator by split type.

Parameters

- **split_type** (*int*)
- **key** (*int*)
- **info** (*Info*)

Return type

Comm

Ssend(*buf, dest, tag=0*)

Blocking send in synchronous mode.

Parameters

- **buf** (*BufSpec*)
- **dest** (*int*)
- **tag** (*int*)

Return type

None

Ssend_init(*buf, dest, tag=0*)

Persistent request for a send in synchronous mode.

Parameters

- **buf** (*BufSpec*)
- **dest** (*int*)
- **tag** (*int*)

Return type

Request

allgather(*sendobj*)

Gather to All.

Parameters

sendobj (*Any*)

Return type

list[Any]

allreduce(*sendobj, op=SUM*)

Reduce to All.

Parameters

- **sendobj** (*Any*)
- **op** (*Op | Callable[[Any, Any], Any]*)

Return type

Any

alltoall(*sendobj*)

All to All Scatter/Gather.

Parameters

sendobj (*Sequence[Any]*)

Return type

list[Any]

barrier()

Barrier synchronization.

Note

This method is equivalent to *Barrier*.

Return type

None

bcast(*obj*, *root=0*)

Broadcast.

Parameters

- **obj** (*Any*)
- **root** (*int*)

Return type

Any

bsend(*obj*, *dest*, *tag=0*)

Send in buffered mode.

Parameters

- **obj** (*Any*)
- **dest** (*int*)
- **tag** (*int*)

Return type

None

classmethod f2py(*arg*)

Parameters

arg (*int*)

Return type

Comm

free()

Call *Free* if not null or predefined.

Return type

None

classmethod fromhandle(*handle*)

Create object from MPI handle.

Parameters

handle (*int*)

Return type

Comm

classmethod fromint(*arg*, /)

Translate integer handle to object.

Parameters

arg (*int*)

Return type

Comm

gather(*sendobj*, *root=0*)

Gather.

Parameters

- **sendobj** (*Any*)

- **root** (*int*)

Return type

list[Any] | None

ibsend(*obj, dest, tag=0*)

Nonblocking send in buffered mode.

Parameters

- **obj** (*Any*)
- **dest** (*int*)
- **tag** (*int*)

Return type

Request

improbe(*source=ANY_SOURCE, tag=ANY_TAG, status=None*)

Nonblocking test for a matched message.

Parameters

- **source** (*int*)
- **tag** (*int*)
- **status** (*Status | None*)

Return type

Message | None

iprobe(*source=ANY_SOURCE, tag=ANY_TAG, status=None*)

Nonblocking test for a message.

Parameters

- **source** (*int*)
- **tag** (*int*)
- **status** (*Status | None*)

Return type

bool

irecv(*buf=None, source=ANY_SOURCE, tag=ANY_TAG*)

Nonblocking receive.

Parameters

- **buf** (*Buffer | None*)
- **source** (*int*)
- **tag** (*int*)

Return type

Request

isend(*obj, dest, tag=0*)

Nonblocking send.

Parameters

- **obj** (*Any*)

- **dest** (*int*)

- **tag** (*int*)

Return type

Request

issend(*obj, dest, tag=0*)

Nonblocking send in synchronous mode.

Parameters

- **obj** (*Any*)

- **dest** (*int*)

- **tag** (*int*)

Return type

Request

mprobe(*source=ANY_SOURCE, tag=ANY_TAG, status=None*)

Blocking test for a matched message.

Parameters

- **source** (*int*)

- **tag** (*int*)

- **status** (*Status | None*)

Return type

Message

probe(*source=ANY_SOURCE, tag=ANY_TAG, status=None*)

Blocking test for a message.

Parameters

- **source** (*int*)

- **tag** (*int*)

- **status** (*Status | None*)

Return type

Literal[True]

py2f()

Return type

int

recv(*buf=None, source=ANY_SOURCE, tag=ANY_TAG, status=None*)

Receive.

Parameters

- **buf** (*Buffer | None*)

- **source** (*int*)

- **tag** (*int*)

- **status** (*Status | None*)

Return type

Any

reduce(*sendobj*, *op*=SUM, *root*=0)

Reduce to Root.

Parameters

- **sendobj** (Any)
- **op** (Op | Callable[[Any, Any], Any])
- **root** (int)

Return type

Any | None

scatter(*sendobj*, *root*=0)

Scatter.

Parameters

- **sendobj** (Sequence[Any] | None)
- **root** (int)

Return type

Any

send(*obj*, *dest*, *tag*=0)

Send in standard mode.

Parameters

- **obj** (Any)
- **dest** (int)
- **tag** (int)

Return type

None

sendrecv(*sendobj*, *dest*, *sendtag*=0, *recvbuf*=None, *source*=ANY_SOURCE, *recvtag*=ANY_TAG, *status*=None)

Send and Receive.

Parameters

- **sendobj** (Any)
- **dest** (int)
- **sendtag** (int)
- **recvbuf** (Buffer | None)
- **source** (int)
- **recvtag** (int)
- **status** (Status | None)

Return type

Any

ssend(*obj*, *dest*, *tag=0*)

Send in synchronous mode.

Parameters

- **obj** (*Any*)
- **dest** (*int*)
- **tag** (*int*)

Return type

None

toint()

Translate object to integer handle.

Return type

int

Attributes Documentation

group

Group.

handle

MPI handle.

info

Info hints.

is_inter

Is intercommunicator.

is_intra

Is intracommunicator.

is_topo

Is a topology.

name

Print name.

rank

Rank of this process.

size

Number of processes.

topology

Topology type.

mpi4py.MPI.Datatype

class mpi4py.MPI.Datatype

Bases: *object*

Datatype object.

static `__new__(cls, datatype=None)`

Parameters

datatype (Datatype | None)

Return type

Self

Methods Summary

<code>Commit()</code>	Commit the datatype.
<code>Create_contiguous(count)</code>	Create a contiguous datatype.
<code>Create_darray(size, rank, gsizes, distribs, ...)</code>	Create a datatype for a distributed array on Cartesian process grids.
<code>Create_f90_complex(p, r)</code>	Return a bounded complex datatype.
<code>Create_f90_integer(r)</code>	Return a bounded integer datatype.
<code>Create_f90_real(p, r)</code>	Return a bounded real datatype.
<code>Create_hindexed(blocklengths, displacements)</code>	Create an indexed datatype.
<code>Create_hindexed_block(blocklength, displacements)</code>	Create an indexed datatype with constant-sized blocks.
<code>Create_hvector(count, blocklength, stride)</code>	Create a vector (strided) datatype with stride in bytes.
<code>Create_indexed(blocklengths, displacements)</code>	Create an indexed datatype.
<code>Create_indexed_block(blocklength, displacements)</code>	Create an indexed datatype with constant-sized blocks.
<code>Create_keyval([copy_fn, delete_fn, nopython])</code>	Create a new attribute key for datatypes.
<code>Create_resized(lb, extent)</code>	Create a datatype with a new lower bound and extent.
<code>Create_struct(blocklengths, displacements, ...)</code>	Create a general composite (struct) datatype.
<code>Create_subarray(sizes, subsizes, starts[, order])</code>	Create a datatype for a subarray of a multidimensional array.
<code>Create_vector(count, blocklength, stride)</code>	Create a vector (strided) datatype.
<code>Delete_attr(keyval)</code>	Delete attribute value associated with a key.
<code>Dup()</code>	Duplicate a datatype.
<code>Free()</code>	Free the datatype.
<code>Free_keyval(keyval)</code>	Free an attribute key for datatypes.
<code>Get_attr(keyval)</code>	Retrieve attribute value by key.
<code>Get_contents()</code>	Return the input arguments used to create a datatype.
<code>Get_envelope()</code>	Return the number of input arguments used to create a datatype.
<code>Get_extent()</code>	Return lower bound and extent of datatype.
<code>Get_name()</code>	Get the print name for this datatype.
<code>Get_size()</code>	Return the number of bytes occupied by entries in the datatype.
<code>Get_true_extent()</code>	Return the true lower bound and extent of a datatype.
<code>Get_value_index(value, index)</code>	Return a predefined pair datatype.
<code>Match_size(typeclass, size)</code>	Find a datatype matching a specified size in bytes.
<code>Pack(inbuf, outbuf, position, comm)</code>	Pack into contiguous memory according to datatype.
<code>Pack_external(datarep, inbuf, outbuf, position)</code>	Pack into contiguous memory according to datatype.
<code>Pack_external_size(datarep, count)</code>	Determine the amount of space needed to pack a message.
<code>Pack_size(count, comm)</code>	Determine the amount of space needed to pack a message.
<code>Set_attr(keyval, attrval)</code>	Store attribute value associated with a key.
<code>Set_name(name)</code>	Set the print name for this datatype.

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<i>Unpack</i> (inbuf, position, outbuf, comm)	Unpack from contiguous memory according to datatype.
<i>Unpack_external</i> (datarep, inbuf, position, outbuf)	Unpack from contiguous memory according to datatype.
<i>decode</i> ()	Convenience method for decoding a datatype.
<i>f2py</i> (arg)	
<i>free</i> ()	Call <i>Free</i> if not null or predefined.
<i>fromcode</i> (code)	Get predefined MPI datatype from character code or type string.
<i>fromhandle</i> (handle)	Create object from MPI handle.
<i>fromint</i> (arg, /)	Translate integer handle to object.
<i>py2f</i> ()	
<i>toencode</i> ()	Get character code or type string from predefined MPI datatype.
<i>toint</i> ()	Translate object to integer handle.

Attributes Summary

<i>combiner</i>	Combiner.
<i>contents</i>	Contents.
<i>envelope</i>	Envelope.
<i>extent</i>	Extent.
<i>handle</i>	MPI handle.
<i>is_named</i>	Is a named datatype.
<i>is_predefined</i>	Is a predefined datatype.
<i>lb</i>	Lower bound.
<i>name</i>	Print name.
<i>size</i>	Size (in bytes).
<i>true_extent</i>	True extent.
<i>true_lb</i>	True lower bound.
<i>true_ub</i>	True upper bound.
<i>typechar</i>	Character code.
<i>typestr</i>	Type string.
<i>ub</i>	Upper bound.

Methods Documentation

Commit()

Commit the datatype.

Return type

Self

Create_contiguous(count)

Create a contiguous datatype.

Parameters

count (*int*)

Return type

Self

Create_darray(*size, rank, gsizes, distribs, dargs, psizes, order=ORDER_C*)

Create a datatype for a distributed array on Cartesian process grids.

Parameters

- **size** (*int*)
- **rank** (*int*)
- **gsizes** (*Sequence[int]*)
- **distribs** (*Sequence[int]*)
- **dargs** (*Sequence[int]*)
- **psizes** (*Sequence[int]*)
- **order** (*int*)

Return type

Self

classmethod Create_f90_complex(*p, r*)

Return a bounded complex datatype.

Parameters

- **p** (*int*)
- **r** (*int*)

Return type

Self

classmethod Create_f90_integer(*r*)

Return a bounded integer datatype.

Parameters

r (*int*)

Return type

Self

classmethod Create_f90_real(*p, r*)

Return a bounded real datatype.

Parameters

- **p** (*int*)
- **r** (*int*)

Return type

Self

Create_hindexed(*blocklengths, displacements*)

Create an indexed datatype.

Note

Displacements are measured in bytes.

Parameters

- **blocklengths** (*Sequence[int]*)
- **displacements** (*Sequence[int]*)

Return type

Self

Create_hindexed_block(*blocklength, displacements*)

Create an indexed datatype with constant-sized blocks.

Note

Displacements are measured in bytes.

Parameters

- **blocklength** (*int*)
- **displacements** (*Sequence[int]*)

Return type

Self

Create_hvector(*count, blocklength, stride*)

Create a vector (strided) datatype with stride in bytes.

Parameters

- **count** (*int*)
- **blocklength** (*int*)
- **stride** (*int*)

Return type

Self

Create_indexed(*blocklengths, displacements*)

Create an indexed datatype.

Parameters

- **blocklengths** (*Sequence[int]*)
- **displacements** (*Sequence[int]*)

Return type

Self

Create_indexed_block(*blocklength, displacements*)

Create an indexed datatype with constant-sized blocks.

Parameters

- **blocklength** (*int*)
- **displacements** (*Sequence[int]*)

Return type

Self

classmethod `Create_keyval`(*copy_fn=None, delete_fn=None, nopython=False*)

Create a new attribute key for datatypes.

Parameters

- **copy_fn** (*Callable*[[Datatype, int, Any], Any] | None)
- **delete_fn** (*Callable*[[Datatype, int, Any], None] | None)
- **nopython** (*bool*)

Return type

int

Create_resized(*lb, extent*)

Create a datatype with a new lower bound and extent.

Parameters

- **lb** (*int*)
- **extent** (*int*)

Return type

Self

classmethod `Create_struct`(*blocklengths, displacements, datatypes*)

Create a general composite (struct) datatype.

Note

Displacements are measured in bytes.

Parameters

- **blocklengths** (*Sequence*[*int*])
- **displacements** (*Sequence*[*int*])
- **datatypes** (*Sequence*[*Datatype*])

Return type

Self

Create_subarray(*sizes, subsizes, starts, order=ORDER_C*)

Create a datatype for a subarray of a multidimensional array.

Parameters

- **sizes** (*Sequence*[*int*])
- **subsizes** (*Sequence*[*int*])
- **starts** (*Sequence*[*int*])
- **order** (*int*)

Return type

Self

Create_vector(*count, blocklength, stride*)

Create a vector (strided) datatype.

Parameters

- **count** (*int*)
- **blocklength** (*int*)
- **stride** (*int*)

Return type

Self

Delete_attr(*keyval*)

Delete attribute value associated with a key.

Parameters

keyval (*int*)

Return type

None

Dup()

Duplicate a datatype.

Return type

Self

Free()

Free the datatype.

Return type

None

classmethod Free_keyval(*keyval*)

Free an attribute key for datatypes.

Parameters

keyval (*int*)

Return type

int

Get_attr(*keyval*)

Retrieve attribute value by key.

Parameters

keyval (*int*)

Return type

int | *Any* | None

Get_contents()

Return the input arguments used to create a datatype.

Return type

tuple[list[int], list[int], list[int], list[Datatype]]

Get_envelope()

Return the number of input arguments used to create a datatype.

Return type
tuple[int, int, int, int, int]

Get_extent()

Return lower bound and extent of datatype.

Return type
tuple[int, int]

Get_name()

Get the print name for this datatype.

Return type
str

Get_size()

Return the number of bytes occupied by entries in the datatype.

Return type
int

Get_true_extent()

Return the true lower bound and extent of a datatype.

Return type
tuple[int, int]

classmethod Get_value_index(value, index)

Return a predefined pair datatype.

Parameters

- **value** (Datatype)
- **index** (Datatype)

Return type
Self

classmethod Match_size(typeclass, size)

Find a datatype matching a specified size in bytes.

Parameters

- **typeclass** (*int*)
- **size** (*int*)

Return type
Self

Pack(inbuf, outbuf, position, comm)

Pack into contiguous memory according to datatype.

Parameters

- **inbuf** (BufSpec)
- **outbuf** (BufSpec)
- **position** (*int*)
- **comm** (Comm)

Return type

`int`

Pack_external(*datarep, inbuf, outbuf, position*)

Pack into contiguous memory according to datatype.

Uses the portable data representation **external32**.

Parameters

- **datarep** (*str*)
- **inbuf** (`BufSpec`)
- **outbuf** (`BufSpec`)
- **position** (*int*)

Return type

`int`

Pack_external_size(*datarep, count*)

Determine the amount of space needed to pack a message.

Uses the portable data representation **external32**.

Note

Returns an upper bound measured in bytes.

Parameters

- **datarep** (*str*)
- **count** (*int*)

Return type

`int`

Pack_size(*count, comm*)

Determine the amount of space needed to pack a message.

Note

Returns an upper bound measured in bytes.

Parameters

- **count** (*int*)
- **comm** (`Comm`)

Return type

`int`

Set_attr(*keyval, attrval*)

Store attribute value associated with a key.

Parameters

- **keyval** (*int*)
- **attrval** (*Any*)

Return type

None

Set_name(*name*)

Set the print name for this datatype.

Parameters

name (*str*)

Return type

None

Unpack(*inbuf, position, outbuf, comm*)

Unpack from contiguous memory according to datatype.

Parameters

- **inbuf** (*BufSpec*)
- **position** (*int*)
- **outbuf** (*BufSpec*)
- **comm** (*Comm*)

Return type

int

Unpack_external(*datarep, inbuf, position, outbuf*)

Unpack from contiguous memory according to datatype.

Uses the portable data representation **external32**.

Parameters

- **datarep** (*str*)
- **inbuf** (*BufSpec*)
- **position** (*int*)
- **outbuf** (*BufSpec*)

Return type

int

decode()

Convenience method for decoding a datatype.

Return type

tuple[*Datatype, str, dict*[*str, Any*]]

classmethod f2py(*arg*)

Parameters

arg (*int*)

Return type

Datatype

free()

Call *Free* if not null or predefined.

Return type

None

classmethod fromcode(*code*)

Get predefined MPI datatype from character code or type string.

Parameters

code (*str*)

Return type

Datatype

classmethod fromhandle(*handle*)

Create object from MPI handle.

Parameters

handle (*int*)

Return type

Datatype

classmethod fromint(*arg*, /)

Translate integer handle to object.

Parameters

arg (*int*)

Return type

Datatype

py2f()

Return type

int

tocode()

Get character code or type string from predefined MPI datatype.

Return type

str

toint()

Translate object to integer handle.

Return type

int

Attributes Documentation

combiner

Combiner.

contents

Contents.

envelope

Envelope.

extent

Extent.

handle

MPI handle.

is_named

Is a named datatype.

is_predefined

Is a predefined datatype.

lb

Lower bound.

name

Print name.

size

Size (in bytes).

true_extent

True extent.

true_lb

True lower bound.

true_ub

True upper bound.

typechar

Character code.

typestr

Type string.

ub

Upper bound.

mpi4py.MPI.Distgraphcomm

class mpi4py.MPI.Distgraphcomm

Bases: *Topocomm*

Distributed graph topology intracommunicator.

static `__new__(cls, comm=None)`

Parameters

`comm` (*Distgraphcomm* / *None*)

Return type

Self

Methods Summary

<code>Get_dist_neighbors()</code>	Return adjacency information for a distributed graph topology.
<code>Get_dist_neighbors_count()</code>	Return adjacency information for a distributed graph topology.

Methods Documentation

`Get_dist_neighbors()`

Return adjacency information for a distributed graph topology.

Return type

`tuple[list[int], list[int], tuple[list[int], list[int]] | None]`

`Get_dist_neighbors_count()`

Return adjacency information for a distributed graph topology.

Return type

`int`

`mpi4py.MPI.Errhandler`

`class mpi4py.MPI.Errhandler`

Bases: `object`

Error handler.

static `__new__(cls, errhandler=None)`

Parameters

errhandler (`Errhandler` | `None`)

Return type

`Self`

Methods Summary

<code>Free()</code>	Free an error handler.
<code>f2py(arg)</code>	
<code>free()</code>	Call <code>Free</code> if not null.
<code>fromhandle(handle)</code>	Create object from MPI handle.
<code>fromint(arg, /)</code>	Translate integer handle to object.
<code>py2f()</code>	
<code>toint()</code>	Translate object to integer handle.

Attributes Summary

<code>handle</code>	MPI handle.
---------------------	-------------

Methods Documentation

Free()

Free an error handler.

Return type

None

classmethod f2py(*arg*)

Parameters

arg (*int*)

Return type

Errhandler

free()

Call *Free* if not null.

Return type

None

classmethod fromhandle(*handle*)

Create object from MPI handle.

Parameters

handle (*int*)

Return type

Errhandler

classmethod fromint(*arg*, /)

Translate integer handle to object.

Parameters

arg (*int*)

Return type

Errhandler

py2f()

Return type

int

toint()

Translate object to integer handle.

Return type

int

Attributes Documentation

handle

MPI handle.

mpi4py.MPI.File

class mpi4py.MPI.File

Bases: `object`

File I/O context.

static `__new__(cls, file=None)`

Parameters

file (`File` | `None`)

Return type

Self

Methods Summary

<code>Call_errhandler</code> (errorcode)	Call the error handler installed on a file.
<code>Close</code> ()	Close a file.
<code>Create_errhandler</code> (errhandler_fn)	Create a new error handler for files.
<code>Delete</code> (filename[, info])	Delete a file.
<code>Get_amode</code> ()	Return the file access mode.
<code>Get_atomicity</code> ()	Return the atomicity mode.
<code>Get_byte_offset</code> (offset)	Return the absolute byte position in the file.
<code>Get_errhandler</code> ()	Get the error handler for a file.
<code>Get_group</code> ()	Access the group of processes that opened the file.
<code>Get_info</code> ()	Return the current hints for a file.
<code>Get_position</code> ()	Return the current position of the individual file pointer.
<code>Get_position_shared</code> ()	Return the current position of the shared file pointer.
<code>Get_size</code> ()	Return the file size.
<code>Get_type_extent</code> (datatype)	Return the extent of datatype in the file.
<code>Get_view</code> ()	Return the file view.
<code>Iread</code> (buf)	Nonblocking read using individual file pointer.
<code>Iread_all</code> (buf)	Nonblocking collective read using individual file pointer.
<code>Iread_at</code> (offset, buf)	Nonblocking read using explicit offset.
<code>Iread_at_all</code> (offset, buf)	Nonblocking collective read using explicit offset.
<code>Iread_shared</code> (buf)	Nonblocking read using shared file pointer.
<code>Iwrite</code> (buf)	Nonblocking write using individual file pointer.
<code>Iwrite_all</code> (buf)	Nonblocking collective write using individual file pointer.
<code>Iwrite_at</code> (offset, buf)	Nonblocking write using explicit offset.
<code>Iwrite_at_all</code> (offset, buf)	Nonblocking collective write using explicit offset.
<code>Iwrite_shared</code> (buf)	Nonblocking write using shared file pointer.
<code>Open</code> (comm, filename[, amode, info])	Open a file.
<code>Preallocate</code> (size)	Preallocate storage space for a file.
<code>Read</code> (buf[, status])	Read using individual file pointer.
<code>Read_all</code> (buf[, status])	Collective read using individual file pointer.
<code>Read_all_begin</code> (buf)	Start a split collective read using individual file pointer.
<code>Read_all_end</code> (buf[, status])	Complete a split collective read using individual file pointer.
<code>Read_at</code> (offset, buf[, status])	Read using explicit offset.
<code>Read_at_all</code> (offset, buf[, status])	Collective read using explicit offset.
<code>Read_at_all_begin</code> (offset, buf)	Start a split collective read using explicit offset.

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<i>Read_at_all_end</i> (buf[, status])	Complete a split collective read using explicit offset.
<i>Read_ordered</i> (buf[, status])	Collective read using shared file pointer.
<i>Read_ordered_begin</i> (buf)	Start a split collective read using shared file pointer.
<i>Read_ordered_end</i> (buf[, status])	Complete a split collective read using shared file pointer.
<i>Read_shared</i> (buf[, status])	Read using shared file pointer.
<i>Seek</i> (offset[, whence])	Update the individual file pointer.
<i>Seek_shared</i> (offset[, whence])	Update the shared file pointer.
<i>Set_atomicsity</i> (flag)	Set the atomicity mode.
<i>Set_errhandler</i> (errhandler)	Set the error handler for a file.
<i>Set_info</i> (info)	Set new values for the hints associated with a file.
<i>Set_size</i> (size)	Set the file size.
<i>Set_view</i> ([disp, etype, filetype, datarep, info])	Set the file view.
<i>Sync</i> ()	Causes all previous writes to be transferred to the storage device.
<i>Write</i> (buf[, status])	Write using individual file pointer.
<i>Write_all</i> (buf[, status])	Collective write using individual file pointer.
<i>Write_all_begin</i> (buf)	Start a split collective write using individual file pointer.
<i>Write_all_end</i> (buf[, status])	Complete a split collective write using individual file pointer.
<i>Write_at</i> (offset, buf[, status])	Write using explicit offset.
<i>Write_at_all</i> (offset, buf[, status])	Collective write using explicit offset.
<i>Write_at_all_begin</i> (offset, buf)	Start a split collective write using explicit offset.
<i>Write_at_all_end</i> (buf[, status])	Complete a split collective write using explicit offset.
<i>Write_ordered</i> (buf[, status])	Collective write using shared file pointer.
<i>Write_ordered_begin</i> (buf)	Start a split collective write using shared file pointer.
<i>Write_ordered_end</i> (buf[, status])	Complete a split collective write using shared file pointer.
<i>Write_shared</i> (buf[, status])	Write using shared file pointer.
<i>f2py</i> (arg)	
<i>free</i> ()	Call <i>Close</i> if not null.
<i>fromhandle</i> (handle)	Create object from MPI handle.
<i>fromint</i> (arg, /)	Translate integer handle to object.
<i>py2f</i> ()	
<i>toint</i> ()	Translate object to integer handle.

Attributes Summary

<i>amode</i>	Access mode.
<i>atomicity</i>	Atomicity mode.
<i>group</i>	Group.
<i>group_rank</i>	Group rank.
<i>group_size</i>	Group size.
<i>handle</i>	MPI handle.
<i>info</i>	Info hints.
<i>size</i>	Size (in bytes).

Methods Documentation

Call_errhandler(*errorcode*)

Call the error handler installed on a file.

Parameters

errorcode (*int*)

Return type

None

Close()

Close a file.

Return type

None

classmethod Create_errhandler(*errhandler_fn*)

Create a new error handler for files.

Parameters

errhandler_fn (*Callable*[[*File*, *int*], *None*])

Return type

Errhandler

classmethod Delete(*filename*, *info=INFO_NULL*)

Delete a file.

Parameters

- **filename** (*PathLike* | *str* | *bytes*)
- **info** (*Info*)

Return type

None

Get_amode()

Return the file access mode.

Return type

int

Get_atomicity()

Return the atomicity mode.

Return type

bool

Get_byte_offset(*offset*)

Return the absolute byte position in the file.

Note

Input *offset* is measured in etype units relative to the current file view.

Parameters
offset (*int*)

Return type
int

Get_errhandler()

Get the error handler for a file.

Return type
Errhandler

Get_group()

Access the group of processes that opened the file.

Return type
Group

Get_info()

Return the current hints for a file.

Return type
Info

Get_position()

Return the current position of the individual file pointer.

Note

Position is measured in etype units relative to the current file view.

Return type
int

Get_position_shared()

Return the current position of the shared file pointer.

Note

Position is measured in etype units relative to the current view.

Return type
int

Get_size()

Return the file size.

Return type
int

Get_type_extent (*datatype*)

Return the extent of datatype in the file.

Parameters
datatype (*Datatype*)

Return type

`int`

Get_view()

Return the file view.

Return type

`tuple[int, Datatype, Datatype, str]`

Iread(*buf*)

Nonblocking read using individual file pointer.

Parameters

buf (`BufSpec`)

Return type

`Request`

Iread_all(*buf*)

Nonblocking collective read using individual file pointer.

Parameters

buf (`BufSpec`)

Return type

`Request`

Iread_at(*offset*, *buf*)

Nonblocking read using explicit offset.

Parameters

- **offset** (`int`)
- **buf** (`BufSpec`)

Return type

`Request`

Iread_at_all(*offset*, *buf*)

Nonblocking collective read using explicit offset.

Parameters

- **offset** (`int`)
- **buf** (`BufSpec`)

Return type

`Request`

Iread_shared(*buf*)

Nonblocking read using shared file pointer.

Parameters

buf (`BufSpec`)

Return type

`Request`

Iwrite(*buf*)

Nonblocking write using individual file pointer.

Parameters

buf (*BufSpec*)

Return type

Request

Iwrite_all(*buf*)

Nonblocking collective write using individual file pointer.

Parameters

buf (*BufSpec*)

Return type

Request

Iwrite_at(*offset, buf*)

Nonblocking write using explicit offset.

Parameters

- **offset** (*int*)
- **buf** (*BufSpec*)

Return type

Request

Iwrite_at_all(*offset, buf*)

Nonblocking collective write using explicit offset.

Parameters

- **offset** (*int*)
- **buf** (*BufSpec*)

Return type

Request

Iwrite_shared(*buf*)

Nonblocking write using shared file pointer.

Parameters

buf (*BufSpec*)

Return type

Request

classmethod **Open**(*comm, filename, amode=MODE_RDONLY, info=INFO_NULL*)

Open a file.

Parameters

- **comm** (*Intracomm*)
- **filename** (*PathLike | str | bytes*)
- **amode** (*int*)
- **info** (*Info*)

Return type

Self

Preallocate(*size*)

Preallocate storage space for a file.

Parameters

size (*int*)

Return type

None

Read(*buf*, *status=None*)

Read using individual file pointer.

Parameters

- **buf** (*BufSpec*)
- **status** (*Status* | *None*)

Return type

None

Read_all(*buf*, *status=None*)

Collective read using individual file pointer.

Parameters

- **buf** (*BufSpec*)
- **status** (*Status* | *None*)

Return type

None

Read_all_begin(*buf*)

Start a split collective read using individual file pointer.

Parameters

buf (*BufSpec*)

Return type

None

Read_all_end(*buf*, *status=None*)

Complete a split collective read using individual file pointer.

Parameters

- **buf** (*BufSpec*)
- **status** (*Status* | *None*)

Return type

None

Read_at(*offset*, *buf*, *status=None*)

Read using explicit offset.

Parameters

- **offset** (*int*)
- **buf** (*BufSpec*)
- **status** (*Status* | *None*)

Return type

None

Read_at_all(*offset*, *buf*, *status=None*)

Collective read using explicit offset.

Parameters

- **offset** (*int*)
- **buf** (*BufSpec*)
- **status** (*Status* | *None*)

Return type

None

Read_at_all_begin(*offset*, *buf*)

Start a split collective read using explicit offset.

Parameters

- **offset** (*int*)
- **buf** (*BufSpec*)

Return type

None

Read_at_all_end(*buf*, *status=None*)

Complete a split collective read using explicit offset.

Parameters

- **buf** (*BufSpec*)
- **status** (*Status* | *None*)

Return type

None

Read_ordered(*buf*, *status=None*)

Collective read using shared file pointer.

Parameters

- **buf** (*BufSpec*)
- **status** (*Status* | *None*)

Return type

None

Read_ordered_begin(*buf*)

Start a split collective read using shared file pointer.

Parameters

buf (*BufSpec*)

Return type

None

Read_ordered_end(*buf*, *status=None*)

Complete a split collective read using shared file pointer.

Parameters

- **buf** (*BufSpec*)
- **status** (*Status* | *None*)

Return type

None

Read_shared(*buf*, *status=None*)

Read using shared file pointer.

Parameters

- **buf** (*BufSpec*)
- **status** (*Status* | *None*)

Return type

None

Seek(*offset*, *whence=SEEK_SET*)

Update the individual file pointer.

Parameters

- **offset** (*int*)
- **whence** (*int*)

Return type

None

Seek_shared(*offset*, *whence=SEEK_SET*)

Update the shared file pointer.

Parameters

- **offset** (*int*)
- **whence** (*int*)

Return type

None

Set_atomicity(*flag*)

Set the atomicity mode.

Parameters

flag (*bool*)

Return type

None

Set_errhandler(*errhandler*)

Set the error handler for a file.

Parameters

errhandler (*Errhandler*)

Return type

None

Set_info(*info*)

Set new values for the hints associated with a file.

Parameters

info (*Info*)

Return type

None

Set_size(*size*)

Set the file size.

Parameters

size (*int*)

Return type

None

Set_view(*disp=0, etype=BYTE, filetype=None, datarep='native', info=INFO_NULL*)

Set the file view.

Parameters

- **disp** (*int*)
- **etype** (*Datatype*)
- **filetype** (*Datatype | None*)
- **datarep** (*str*)
- **info** (*Info*)

Return type

None

Sync()

Causes all previous writes to be transferred to the storage device.

Return type

None

Write(*buf, status=None*)

Write using individual file pointer.

Parameters

- **buf** (*BufSpec*)
- **status** (*Status | None*)

Return type

None

Write_all(*buf, status=None*)

Collective write using individual file pointer.

Parameters

- **buf** (*BufSpec*)
- **status** (*Status | None*)

Return type

None

Write_all_begin(*buf*)

Start a split collective write using individual file pointer.

Parameters

buf (BufSpec)

Return type

None

Write_all_end(*buf*, *status=None*)

Complete a split collective write using individual file pointer.

Parameters

- **buf** (BufSpec)
- **status** (Status | None)

Return type

None

Write_at(*offset*, *buf*, *status=None*)

Write using explicit offset.

Parameters

- **offset** (*int*)
- **buf** (BufSpec)
- **status** (Status | None)

Return type

None

Write_at_all(*offset*, *buf*, *status=None*)

Collective write using explicit offset.

Parameters

- **offset** (*int*)
- **buf** (BufSpec)
- **status** (Status | None)

Return type

None

Write_at_all_begin(*offset*, *buf*)

Start a split collective write using explicit offset.

Parameters

- **offset** (*int*)
- **buf** (BufSpec)

Return type

None

Write_at_all_end(*buf*, *status=None*)

Complete a split collective write using explicit offset.

Parameters

- **buf** (*BufSpec*)
- **status** (*Status* | *None*)

Return type

None

Write_ordered(*buf*, *status=None*)

Collective write using shared file pointer.

Parameters

- **buf** (*BufSpec*)
- **status** (*Status* | *None*)

Return type

None

Write_ordered_begin(*buf*)

Start a split collective write using shared file pointer.

Parameters

buf (*BufSpec*)

Return type

None

Write_ordered_end(*buf*, *status=None*)

Complete a split collective write using shared file pointer.

Parameters

- **buf** (*BufSpec*)
- **status** (*Status* | *None*)

Return type

None

Write_shared(*buf*, *status=None*)

Write using shared file pointer.

Parameters

- **buf** (*BufSpec*)
- **status** (*Status* | *None*)

Return type

None

classmethod f2py(*arg*)

Parameters

arg (*int*)

Return type

File

free()

Call *Close* if not null.

Return type

None

classmethod fromhandle(*handle*)

Create object from MPI handle.

Parameters

handle (*int*)

Return type

File

classmethod fromint(*arg*, /)

Translate integer handle to object.

Parameters

arg (*int*)

Return type

File

py2f()

Return type

int

toint()

Translate object to integer handle.

Return type

int

Attributes Documentation

amode

Access mode.

atomicity

Atomicity mode.

group

Group.

group_rank

Group rank.

group_size

Group size.

handle

MPI handle.

info

Info hints.

size

Size (in bytes).

mpi4py.MPI.Graphcomm

class mpi4py.MPI.Graphcomm

Bases: *Topocomm*

General graph topology intracommunicator.

static `__new__(cls, comm=None)`

Parameters

comm (*Graphcomm* | *None*)

Return type

Self

Methods Summary

<code>Get_dims()</code>	Return the number of nodes and edges.
<code>Get_neighbors(rank)</code>	Return list of neighbors of a process.
<code>Get_neighbors_count(rank)</code>	Return number of neighbors of a process.
<code>Get_topo()</code>	Return index and edges.

Attributes Summary

<code>dims</code>	Number of nodes and edges.
<code>edges</code>	Edges.
<code>index</code>	Index.
<code>nedges</code>	Number of edges.
<code>neighbors</code>	Neighbors.
<code>nneighbors</code>	Number of neighbors.
<code>nnodes</code>	Number of nodes.
<code>topo</code>	Topology information.

Methods Documentation

`Get_dims()`

Return the number of nodes and edges.

Return type

`tuple[int, int]`

`Get_neighbors(rank)`

Return list of neighbors of a process.

Parameters

rank (*int*)

Return type

`list[int]`

`Get_neighbors_count(rank)`

Return number of neighbors of a process.

Parameters

rank (*int*)

Return type

int

Get_topo()

Return index and edges.

Return type

tuple[list[int], list[int]]

Attributes Documentation**dims**

Number of nodes and edges.

edges

Edges.

index

Index.

nedges

Number of edges.

neighbors

Neighbors.

nneighbors

Number of neighbors.

nnodes

Number of nodes.

topo

Topology information.

mpi4py.MPI.Grequest**class mpi4py.MPI.Grequest**Bases: *Request*

Generalized request handler.

static `__new__(cls, request=None)`**Parameters****request** (*Grequest* | *None*)**Return type***Self***Methods Summary**

<code>Complete()</code>	Notify that a user-defined request is complete.
<code>Start([query_fn, free_fn, cancel_fn, args, ...])</code>	Create and return a user-defined request.
<code>complete([obj])</code>	Notify that a user-defined request is complete.

Methods Documentation

Complete()

Notify that a user-defined request is complete.

Return type

None

classmethod Start(*query_fn=None, free_fn=None, cancel_fn=None, args=None, kwargs=None*)

Create and return a user-defined request.

Parameters

- **query_fn** (*Callable*[[...], None] | None)
- **free_fn** (*Callable*[[...], None] | None)
- **cancel_fn** (*Callable*[[...], None] | None)
- **args** (*tuple*[Any] | None)
- **kwargs** (*dict*[str, Any] | None)

Return type

Grequest

complete(*obj=None*)

Notify that a user-defined request is complete.

Parameters

obj (*Any*)

Return type

None

mpi4py.MPI.Group

class mpi4py.MPI.Group

Bases: `object`

Group of processes.

static __new__(cls, group=None)

Parameters

group (`Group` | None)

Return type

Self

Methods Summary

<code>Compare(group)</code>	Compare two groups.
<code>Create_from_session_pset(session, pset_name)</code>	Create a new group from session and process set.
<code>Difference(group1, group2)</code>	Create a new group from the difference of two existing groups.
<code>Dup()</code>	Duplicate a group.
<code>Excl(ranks)</code>	Create a new group by excluding listed members.
<code>Free()</code>	Free a group.
<code>Get_rank()</code>	Return the rank of this process in a group.

continues on next page

Table 34 – continued from previous page

<i>Get_size</i> ()	Return the number of processes in a group.
<i>Incl</i> (ranks)	Create a new group by including listed members.
<i>Intersection</i> (group1, group2)	Create a new group from the intersection of two existing groups.
<i>Range_excl</i> (ranks)	Create a new group by excluding ranges of members.
<i>Range_incl</i> (ranks)	Create a new group by including ranges of members.
<i>Translate_ranks</i> ([ranks, group])	Translate ranks in a group to those in another group.
<i>Union</i> (group1, group2)	Create a new group from the union of two existing groups.
<i>f2py</i> (arg)	
<i>free</i> ()	Call <i>Free</i> if not null or predefined.
<i>fromhandle</i> (handle)	Create object from MPI handle.
<i>fromint</i> (arg, /)	Translate integer handle to object.
<i>py2f</i> ()	
<i>toint</i> ()	Translate object to integer handle.

Attributes Summary

<i>handle</i>	MPI handle.
<i>rank</i>	Rank of this process.
<i>size</i>	Number of processes.

Methods Documentation

Compare(*group*)

Compare two groups.

Parameters

group (*Group*)

Return type

int

classmethod Create_from_session_pset(*session, pset_name*)

Create a new group from session and process set.

Parameters

- **session** (*Session*)
- **pset_name** (*str*)

Return type

Self

classmethod Difference(*group1, group2*)

Create a new group from the difference of two existing groups.

Parameters

- **group1** (*Group*)
- **group2** (*Group*)

Return type

Self

Dup()

Duplicate a group.

Return type

Self

Excl(ranks)

Create a new group by excluding listed members.

Parameters

ranks (*Sequence[int]*)

Return type

Self

Free()

Free a group.

Return type

None

Get_rank()

Return the rank of this process in a group.

Return type

int

Get_size()

Return the number of processes in a group.

Return type

int

Incl(ranks)

Create a new group by including listed members.

Parameters

ranks (*Sequence[int]*)

Return type

Self

classmethod Intersection(group1, group2)

Create a new group from the intersection of two existing groups.

Parameters

- **group1** (*Group*)
- **group2** (*Group*)

Return type

Self

Range_excl(ranks)

Create a new group by excluding ranges of members.

Parameters

ranks (*Sequence[tuple[int, int, int]]*)

Return type*Self***Range_incl**(*ranks*)

Create a new group by including ranges of members.

Parameters**ranks** (*Sequence*[*tuple*[*int*, *int*, *int*]])**Return type***Self***Translate_ranks**(*ranks=None*, *group=None*)

Translate ranks in a group to those in another group.

Parameters

- **ranks** (*Sequence*[*int*] | *None*)
- **group** (*Group* | *None*)

Return type*list*[*int*]**classmethod Union**(*group1*, *group2*)

Create a new group from the union of two existing groups.

Parameters

- **group1** (*Group*)
- **group2** (*Group*)

Return type*Self***classmethod f2py**(*arg*)**Parameters****arg** (*int*)**Return type***Group***free**()

Call *Free* if not null or predefined.

Return type*None***classmethod fromhandle**(*handle*)

Create object from MPI handle.

Parameters**handle** (*int*)**Return type***Group***classmethod fromint**(*arg*, /)

Translate integer handle to object.

Parameters**arg** (*int*)

Return type

Group

py2f()**Return type**

int

toint()

Translate object to integer handle.

Return type

int

Attributes Documentation**handle**

MPI handle.

rank

Rank of this process.

size

Number of processes.

mpi4py.MPI.InPlaceType**class** mpi4py.MPI.InPlaceType

Bases: object

Type of *IN_PLACE*.**static** `__new__(cls)`**Return type***Self***mpi4py.MPI.Info****class** mpi4py.MPI.Info

Bases: object

Info object.

static `__new__(cls, info=None)`**Parameters****info** (Info | None)**Return type***Self***Methods Summary**

<code>Create([items])</code>	Create a new info object.
<code>Create_env([args])</code>	Create a new environment info object.
<code>Delete(key)</code>	Remove a (key, value) pair from info.

continues on next page

Table 36 – continued from previous page

<i>Dup()</i>	Duplicate an existing info object.
<i>Free()</i>	Free an info object.
<i>Get(key)</i>	Retrieve the value associated with a key.
<i>Get_nkeys()</i>	Return the number of currently defined keys in info.
<i>Get_nthkey(n)</i>	Return the <i>n</i> -th defined key in info.
<i>Set(key, value)</i>	Store a value associated with a key.
<i>clear()</i>	Clear contents.
<i>copy()</i>	Copy contents.
<i>f2py(arg)</i>	
<i>free()</i>	Call <i>Free</i> if not null or predefined.
<i>fromhandle(handle)</i>	Create object from MPI handle.
<i>fromint(arg, /)</i>	Translate integer handle to object.
<i>get(key[, default])</i>	Retrieve value by key.
<i>items()</i>	Return list of items.
<i>keys()</i>	Return list of keys.
<i>pop(key, *default)</i>	Pop value by key.
<i>popitem()</i>	Pop first item.
<i>py2f()</i>	
<i>toint()</i>	Translate object to integer handle.
<i>update([items])</i>	Update contents.
<i>values()</i>	Return list of values.

Attributes Summary

<i>handle</i>	MPI handle.
---------------	-------------

Methods Documentation

classmethod Create(*items=None*)

Create a new info object.

Parameters

items (*Info* | *Mapping*[*str*, *str*] | *Iterable*[*tuple*[*str*, *str*]] | *None*)

Return type

Self

classmethod Create_env(*args=None*)

Create a new environment info object.

Parameters

args (*Sequence*[*str*] | *None*)

Return type

Self

Delete(*key*)

Remove a (key, value) pair from info.

Parameters

key (*str*)

Return type

None

Dup()

Duplicate an existing info object.

Return type

Self

Free()

Free an info object.

Return type

None

Get(*key*)

Retrieve the value associated with a key.

Parameters

key (*str*)

Return type

str | None

Get_nkeys()

Return the number of currently defined keys in info.

Return type

int

Get_nthkey(*n*)

Return the *n*-th defined key in info.

Parameters

n (*int*)

Return type

str

Set(*key, value*)

Store a value associated with a key.

Parameters

- **key** (*str*)
- **value** (*str*)

Return type

None

clear()

Clear contents.

Return type

None

copy()

Copy contents.

Return type

Self

classmethod `f2py(arg)`

Parameters

arg (*int*)

Return type

Info

free()

Call *Free* if not null or predefined.

Return type

None

classmethod `fromhandle(handle)`

Create object from MPI handle.

Parameters

handle (*int*)

Return type

Info

classmethod `fromint(arg, /)`

Translate integer handle to object.

Parameters

arg (*int*)

Return type

Info

get(*key*, *default=None*)

Retrieve value by key.

Parameters

- **key** (*str*)
- **default** (*str* | *None*)

Return type

str | *None*

items()

Return list of items.

Return type

list[*tuple*[*str*, *str*]]

keys()

Return list of keys.

Return type

list[*str*]

pop(*key*, **default*)

Pop value by key.

Parameters

- **key** (*str*)
- **default** (*str*)

Return type

str

popitem()

Pop first item.

Return type

tuple[str, str]

py2f()**Return type**

int

toint()

Translate object to integer handle.

Return type

int

update(*items=()*, *kws*)**

Update contents.

Parameters

- **items** (*Info* | *Mapping*[str, str] | *Iterable*[tuple[str, str]])
- **kws** (*str*)

Return type

None

values()

Return list of values.

Return type

list[str]

Attributes Documentation**handle**

MPI handle.

mpi4py.MPI.Intercomm**class** mpi4py.MPI.Intercomm

Bases: *Comm*

Intercommunicator.

static `__new__(cls, comm=None)`**Parameters**

comm (*Intercomm* | *None*)

Return type

Self

Methods Summary

<code>Create_from_groups(local_group, ...[, ...])</code>	Create communicator from group.
<code>Get_remote_group()</code>	Access the remote group associated with the inter-communicator.
<code>Get_remote_size()</code>	Intercommunicator remote size.
<code>Merge([high])</code>	Merge intercommunicator into an intracommunicator.

Attributes Summary

<code>remote_group</code>	Remote group.
<code>remote_size</code>	Number of remote processes.

Methods Documentation

classmethod `Create_from_groups`(*local_group*, *local_leader*, *remote_group*, *remote_leader*, *stringtag*='org.mpi4py', *info*=INFO_NULL, *errhandler*=None)

Create communicator from group.

Parameters

- **local_group** (*Group*)
- **local_leader** (*int*)
- **remote_group** (*Group*)
- **remote_leader** (*int*)
- **stringtag** (*str*)
- **info** (*Info*)
- **errhandler** (*Errhandler* / *None*)

Return type

Intracomm

Get_remote_group()

Access the remote group associated with the inter-communicator.

Return type

Group

Get_remote_size()

Intercommunicator remote size.

Return type

int

Merge(*high*=False)

Merge intercommunicator into an intracommunicator.

Parameters

- **high** (*bool*)

Return type

Intracomm

Attributes Documentation

remote_group

Remote group.

remote_size

Number of remote processes.

mpi4py.MPI.Intracomm

class mpi4py.MPI.Intracomm

Bases: *Comm*

Intracommunicator.

static `__new__(cls, comm=None)`

Parameters

comm (*Intracomm* / *None*)

Return type

Self

Methods Summary

<i>Accept</i> (port_name[, info, root])	Accept a request to form a new intercommunicator.
<i>Cart_map</i> (dims[, periods])	Determine optimal process placement on a Cartesian topology.
<i>Connect</i> (port_name[, info, root])	Make a request to form a new intercommunicator.
<i>Create_cart</i> (dims[, periods, reorder])	Create cartesian communicator.
<i>Create_dist_graph</i> (sources, degrees, destinations)	Create distributed graph communicator.
<i>Create_dist_graph_adjacent</i> (sources, destinations)	Create distributed graph communicator.
<i>Create_from_group</i> (group[, stringtag, info, ...])	Create communicator from group.
<i>Create_graph</i> (index, edges[, reorder])	Create graph communicator.
<i>Create_group</i> (group[, tag])	Create communicator from group.
<i>Create_intercomm</i> (local_leader, peer_comm, ...)	Create intercommunicator.
<i>Exscan</i> (sendbuf, recvbuf[, op])	Exclusive Scan.
<i>Exscan_init</i> (sendbuf, recvbuf[, op, info])	Persistent Exclusive Scan.
<i>Graph_map</i> (index, edges)	Determine optimal process placement on a graph topology.
<i>Iexscan</i> (sendbuf, recvbuf[, op])	Inclusive Scan.
<i>Iscan</i> (sendbuf, recvbuf[, op])	Inclusive Scan.
<i>Scan</i> (sendbuf, recvbuf[, op])	Inclusive Scan.
<i>Scan_init</i> (sendbuf, recvbuf[, op, info])	Persistent Inclusive Scan.
<i>Spawn</i> (command[, args, maxprocs, info, root, ...])	Spawn instances of a single MPI application.
<i>Spawn_multiple</i> (command[, args, maxprocs, ...])	Spawn instances of multiple MPI applications.
<i>exscan</i> (sendobj[, op])	Exclusive Scan.
<i>scan</i> (sendobj[, op])	Inclusive Scan.

Methods Documentation

Accept(*port_name*, *info=INFO_NULL*, *root=0*)

Accept a request to form a new intercommunicator.

Parameters

- **port_name** (*str*)
- **info** (*Info*)
- **root** (*int*)

Return type

Intercomm

Cart_map(*dims*, *periods=None*)

Determine optimal process placement on a Cartesian topology.

Parameters

- **dims** (*Sequence[int]*)
- **periods** (*Sequence[bool] | None*)

Return type

int

Connect(*port_name*, *info=INFO_NULL*, *root=0*)

Make a request to form a new intercommunicator.

Parameters

- **port_name** (*str*)
- **info** (*Info*)
- **root** (*int*)

Return type

Intercomm

Create_cart(*dims*, *periods=None*, *reorder=False*)

Create cartesian communicator.

Parameters

- **dims** (*Sequence[int]*)
- **periods** (*Sequence[bool] | None*)
- **reorder** (*bool*)

Return type

Cartcomm

Create_dist_graph(*sources*, *degrees*, *destinations*, *weights=None*, *info=INFO_NULL*, *reorder=False*)

Create distributed graph communicator.

Parameters

- **sources** (*Sequence[int]*)
- **degrees** (*Sequence[int]*)

- **destinations** (*Sequence[int]*)
- **weights** (*Sequence[int] | None*)
- **info** (*Info*)
- **reorder** (*bool*)

Return type

Distgraphcomm

Create_dist_graph_adjacent(*sources, destinations, sourceweights=None, destweights=None, info=INFO_NULL, reorder=False*)

Create distributed graph communicator.

Parameters

- **sources** (*Sequence[int]*)
- **destinations** (*Sequence[int]*)
- **sourceweights** (*Sequence[int] | None*)
- **destweights** (*Sequence[int] | None*)
- **info** (*Info*)
- **reorder** (*bool*)

Return type

Distgraphcomm

classmethod Create_from_group(*group, stringtag='org.mpi4py', info=INFO_NULL, errhandler=None*)

Create communicator from group.

Parameters

- **group** (*Group*)
- **stringtag** (*str*)
- **info** (*Info*)
- **errhandler** (*Errhandler | None*)

Return type

Intracomm

Create_graph(*index, edges, reorder=False*)

Create graph communicator.

Parameters

- **index** (*Sequence[int]*)
- **edges** (*Sequence[int]*)
- **reorder** (*bool*)

Return type

Graphcomm

Create_group(*group, tag=0*)

Create communicator from group.

Parameters

- **group** (*Group*)
- **tag** (*int*)

Return type
Intracomm

Create_intercomm(*local_leader, peer_comm, remote_leader, tag=0*)

Create intercommunicator.

Parameters

- **local_leader** (*int*)
- **peer_comm** (*Intracomm*)
- **remote_leader** (*int*)
- **tag** (*int*)

Return type
Intercomm

Exscan(*sendbuf, recvbuf, op=SUM*)

Exclusive Scan.

Parameters

- **sendbuf** (*BufSpec / InPlace*)
- **recvbuf** (*BufSpec*)
- **op** (*Op*)

Return type
None

Exscan_init(*sendbuf, recvbuf, op=SUM, info=INFO_NULL*)

Persistent Exclusive Scan.

Parameters

- **sendbuf** (*BufSpec / InPlace*)
- **recvbuf** (*BufSpec*)
- **op** (*Op*)
- **info** (*Info*)

Return type
Prequest

Graph_map(*index, edges*)

Determine optimal process placement on a graph topology.

Parameters

- **index** (*Sequence[int]*)
- **edges** (*Sequence[int]*)

Return type
int

Iexscan(*sendbuf*, *recvbuf*, *op=SUM*)

Inclusive Scan.

Parameters

- **sendbuf** (BufSpec / InPlace)
- **recvbuf** (BufSpec)
- **op** (Op)

Return type

Request

Iscan(*sendbuf*, *recvbuf*, *op=SUM*)

Inclusive Scan.

Parameters

- **sendbuf** (BufSpec / InPlace)
- **recvbuf** (BufSpec)
- **op** (Op)

Return type

Request

Scan(*sendbuf*, *recvbuf*, *op=SUM*)

Inclusive Scan.

Parameters

- **sendbuf** (BufSpec / InPlace)
- **recvbuf** (BufSpec)
- **op** (Op)

Return type

None

Scan_init(*sendbuf*, *recvbuf*, *op=SUM*, *info=INFO_NULL*)

Persistent Inclusive Scan.

Parameters

- **sendbuf** (BufSpec / InPlace)
- **recvbuf** (BufSpec)
- **op** (Op)
- **info** (Info)

Return type

Prequest

Spawn(*command*, *args=None*, *maxprocs=1*, *info=INFO_NULL*, *root=0*, *errcodes=None*)

Spawn instances of a single MPI application.

Parameters

- **command** (PathLike | str | bytes)
- **args** (Sequence[str] | None)

- **maxprocs** (*int*)
- **info** (*Info*)
- **root** (*int*)
- **errcodes** (*list[int] | None*)

Return type

Intercomm

Spawn_multiple(*command, args=None, maxprocs=None, info=INFO_NULL, root=0, errcodes=None*)

Spawn instances of multiple MPI applications.

Parameters

- **command** (*Sequence[PathLike | str | bytes]*)
- **args** (*Sequence[Sequence[str]] | None*)
- **maxprocs** (*Sequence[int] | None*)
- **info** (*Sequence[Info] | Info*)
- **root** (*int*)
- **errcodes** (*list[list[int]] | None*)

Return type

Intercomm

exscan(*sendobj, op=SUM*)

Exclusive Scan.

Parameters

- **sendobj** (*Any*)
- **op** (*Op | Callable[[Any, Any], Any]*)

Return type

Any

scan(*sendobj, op=SUM*)

Inclusive Scan.

Parameters

- **sendobj** (*Any*)
- **op** (*Op | Callable[[Any, Any], Any]*)

Return type

Any

mpi4py.MPI.Message

class `mpi4py.MPI.Message`

Bases: `object`

Matched message.

static `__new__(cls, message=None)`

Parameters

message (*Message | None*)

Return type

Self

Methods Summary

<i>Iprobe</i> (comm[, source, tag, status])	Nonblocking test for a matched message.
<i>Irecv</i> (buf)	Nonblocking receive of matched message.
<i>Probe</i> (comm[, source, tag, status])	Blocking test for a matched message.
<i>Recv</i> (buf[, status])	Blocking receive of matched message.
<i>f2py</i> (arg)	
<i>free</i> ()	Do nothing.
<i>fromhandle</i> (handle)	Create object from MPI handle.
<i>fromint</i> (arg, /)	Translate integer handle to object.
<i>iprobe</i> (comm[, source, tag, status])	Nonblocking test for a matched message.
<i>irecv</i> ()	Nonblocking receive of matched message.
<i>probe</i> (comm[, source, tag, status])	Blocking test for a matched message.
<i>py2f</i> ()	
<i>recv</i> ([status])	Blocking receive of matched message.
<i>toint</i> ()	Translate object to integer handle.

Attributes Summary

<i>handle</i>	MPI handle.
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Methods Documentation

classmethod *Iprobe*(comm, source=ANY_SOURCE, tag=ANY_TAG, status=None)

Nonblocking test for a matched message.

Parameters

- **comm** (*Comm*)
- **source** (*int*)
- **tag** (*int*)
- **status** (*Status* | *None*)

Return type

Self | *None*

irecv(buf)

Nonblocking receive of matched message.

Parameters

buf (*BufSpec*)

Return type

Request

classmethod *Probe*(comm, source=ANY_SOURCE, tag=ANY_TAG, status=None)

Blocking test for a matched message.

Parameters

- **comm** (*Comm*)
- **source** (*int*)
- **tag** (*int*)
- **status** (*Status* | *None*)

Return type

Self

Recv(*buf*, *status=None*)

Blocking receive of matched message.

Parameters

- **buf** (*BufSpec*)
- **status** (*Status* | *None*)

Return type

None

classmethod f2py(*arg*)

Parameters

arg (*int*)

Return type

Message

free()

Do nothing.

Return type

None

classmethod fromhandle(*handle*)

Create object from MPI handle.

Parameters

handle (*int*)

Return type

Message

classmethod fromint(*arg*, /)

Translate integer handle to object.

Parameters

arg (*int*)

Return type

Message

classmethod iprobe(*comm*, *source=ANY_SOURCE*, *tag=ANY_TAG*, *status=None*)

Nonblocking test for a matched message.

Parameters

- **comm** (*Comm*)
- **source** (*int*)

- **tag** (*int*)
- **status** (*Status | None*)

Return type
Self | None

irecv()

Nonblocking receive of matched message.

Return type
Request

classmethod probe(*comm, source=ANY_SOURCE, tag=ANY_TAG, status=None*)

Blocking test for a matched message.

Parameters

- **comm** (*Comm*)
- **source** (*int*)
- **tag** (*int*)
- **status** (*Status | None*)

Return type
Self

py2f()

Return type
int

recv(*status=None*)

Blocking receive of matched message.

Parameters

status (*Status | None*)

Return type
Any

toint()

Translate object to integer handle.

Return type
int

Attributes Documentation

handle

MPI handle.

mpi4py.MPI.Op

class `mpi4py.MPI.Op`

Bases: `object`

Reduction operation.

static `__new__(cls, op=None)`

Parameters

op (*Op* | *None*)

Return type

Self

Methods Summary

<code>Create</code> (function[, commute])	Create a user-defined reduction operation.
<code>Free</code> ()	Free a user-defined reduction operation.
<code>Is_commutative</code> ()	Query reduction operations for their commutativity.
<code>Reduce_local</code> (inbuf, inoutbuf)	Apply a reduction operation to local data.
<code>f2py</code> (arg)	
<code>free</code> ()	Call <code>Free</code> if not null or predefined.
<code>fromhandle</code> (handle)	Create object from MPI handle.
<code>fromint</code> (arg, /)	Translate integer handle to object.
<code>py2f</code> ()	
<code>toint</code> ()	Translate object to integer handle.

Attributes Summary

<code>handle</code>	MPI handle.
<code>is_commutative</code>	Is a commutative operation.
<code>is_predefined</code>	Is a predefined operation.

Methods Documentation

classmethod `Create`(function, commute=False)

Create a user-defined reduction operation.

Parameters

- **function** (*Callable*[[*Buffer*, *Buffer*, *Datatype*], *None*])
- **commute** (*bool*)

Return type

Self

Free()

Free a user-defined reduction operation.

Return type

None

Is_commutative()

Query reduction operations for their commutativity.

Return type

bool

Reduce_local(*inbuf*, *inoutbuf*)

Apply a reduction operation to local data.

Parameters

- **inbuf** (BufSpec)
- **inoutbuf** (BufSpec)

Return type

None

classmethod f2py(*arg*)

Parameters

arg (*int*)

Return type

Op

free()

Call *Free* if not null or predefined.

Return type

None

classmethod fromhandle(*handle*)

Create object from MPI handle.

Parameters

handle (*int*)

Return type

Op

classmethod fromint(*arg*, /)

Translate integer handle to object.

Parameters

arg (*int*)

Return type

Op

py2f()

Return type

int

toint()

Translate object to integer handle.

Return type

int

Attributes Documentation

handle

MPI handle.

is_commutative

Is a commutative operation.

is_predefined

Is a predefined operation.

mpi4py.MPI.Pickle

class mpi4py.MPI.Pickle

Bases: `object`

Pickle/unpickle Python objects.

static `__new__(cls, pickle=None)`

Parameters

pickle (`Pickle` | `None`)

Return type

Self

Methods Summary

<code>dump(obj)</code>	Serialize object to pickle data stream.
<code>dump_oob(obj)</code>	Serialize object to pickle data stream and out-of-band buffers.
<code>load(data)</code>	Deserialize object from pickle data stream.
<code>load_oob(data, buffers)</code>	Deserialize object from pickle data stream and out-of-band buffers.

Attributes Summary

<code>PROTOCOL</code>	Protocol version.
<code>THRESHOLD</code>	Out-of-band threshold.

Methods Documentation

dump(*obj*)

Serialize object to pickle data stream.

Parameters

obj (*Any*)

Return type

bytes

dump_oob(*obj*)

Serialize object to pickle data stream and out-of-band buffers.

Parameters

obj (*Any*)

Return type

tuple[bytes, list[buffer]]

load(*data*)

Deserialize object from pickle data stream.

Parameters**data** (*Buffer*)**Return type***Any***loads_oob**(*data*, *buffers*)

Deserialize object from pickle data stream and out-of-band buffers.

Parameters

- **data** (*Buffer*)
- **buffers** (*Iterable*[*Buffer*])

Return type*Any***Attributes Documentation****PROTOCOL**

Protocol version.

THRESHOLD

Out-of-band threshold.

mpi4py.MPI.Prequest**class** `mpi4py.MPI.Prequest`Bases: *Request*

Persistent request handler.

static `__new__(cls, request=None)`**Parameters****request** (*Prequest* | *None*)**Return type***Self***Methods Summary**

<i>Parrived</i> (partition)	Test partial completion of a partitioned receive operation.
<i>Pready</i> (partition)	Mark a given partition as ready.
<i>Pready_list</i> (partitions)	Mark a sequence of partitions as ready.
<i>Pready_range</i> (partition_low, partition_high)	Mark a range of partitions as ready.
<i>Start</i> ()	Initiate a communication with a persistent request.
<i>Startall</i> (requests)	Start a collection of persistent requests.

Methods Documentation**Parrived**(*partition*)

Test partial completion of a partitioned receive operation.

Parameters**partition** (*int*)

Return type

bool

Pready(*partition*)

Mark a given partition as ready.

Parameters

partition (*int*)

Return type

None

Pready_list(*partitions*)

Mark a sequence of partitions as ready.

Parameters

partitions (*Sequence*[*int*])

Return type

None

Pready_range(*partition_low*, *partition_high*)

Mark a range of partitions as ready.

Parameters

- **partition_low** (*int*)
- **partition_high** (*int*)

Return type

None

Start()

Initiate a communication with a persistent request.

Return type

None

classmethod Startall(*requests*)

Start a collection of persistent requests.

Parameters

requests (*list* [*Prequest*])

Return type

None

mpi4py.MPI.Request**class** mpi4py.MPI.Request

Bases: *object*

Request handler.

static **__new__**(*cls*, *request=None*)

Parameters

request (*Request* | *None*)

Return type

Self

Methods Summary

<i>Cancel()</i>	Cancel a request.
<i>Free()</i>	Free a communication request.
<i>Get_status</i> ([status])	Non-destructive test for the completion of a request.
<i>Get_status_all</i> (requests[, statuses])	Non-destructive test for the completion of all requests.
<i>Get_status_any</i> (requests[, status])	Non-destructive test for the completion of any requests.
<i>Get_status_some</i> (requests[, statuses])	Non-destructive test for completion of some requests.
<i>Test</i> ([status])	Test for the completion of a non-blocking operation.
<i>Testall</i> (requests[, statuses])	Test for completion of all previously initiated requests.
<i>Testany</i> (requests[, status])	Test for completion of any previously initiated request.
<i>Testsome</i> (requests[, statuses])	Test for completion of some previously initiated requests.
<i>Wait</i> ([status])	Wait for a non-blocking operation to complete.
<i>Waitall</i> (requests[, statuses])	Wait for all previously initiated requests to complete.
<i>Waitany</i> (requests[, status])	Wait for any previously initiated request to complete.
<i>Waitsome</i> (requests[, statuses])	Wait for some previously initiated requests to complete.
<i>cancel()</i>	Cancel a request.
<i>f2py</i> (arg)	
<i>free()</i>	Call <i>Free</i> if not null.
<i>fromhandle</i> (handle)	Create object from MPI handle.
<i>fromint</i> (arg, /)	Translate integer handle to object.
<i>get_status</i> ([status])	Non-destructive test for the completion of a request.
<i>get_status_all</i> (requests[, statuses])	Non-destructive test for the completion of all requests.
<i>get_status_any</i> (requests[, status])	Non-destructive test for the completion of any requests.
<i>get_status_some</i> (requests[, statuses])	Non-destructive test for completion of some requests.
<i>py2f</i> ()	
<i>test</i> ([status])	Test for the completion of a non-blocking operation.
<i>testall</i> (requests[, statuses])	Test for completion of all previously initiated requests.
<i>testany</i> (requests[, status])	Test for completion of any previously initiated request.
<i>testsome</i> (requests[, statuses])	Test for completion of some previously initiated requests.
<i>toint</i> ()	Translate object to integer handle.
<i>wait</i> ([status])	Wait for a non-blocking operation to complete.
<i>waitall</i> (requests[, statuses])	Wait for all previously initiated requests to complete.
<i>waitany</i> (requests[, status])	Wait for any previously initiated request to complete.
<i>waitsome</i> (requests[, statuses])	Wait for some previously initiated requests to complete.

Attributes Summary

handle

MPI handle.

Methods Documentation

Cancel()

Cancel a request.

Return type

None

Free()

Free a communication request.

Return type

None

Get_status(*status=None*)

Non-destructive test for the completion of a request.

Parameters

status (*Status* | *None*)

Return type

bool

classmethod Get_status_all(*requests, statuses=None*)

Non-destructive test for the completion of all requests.

Parameters

- **requests** (*Sequence* [*Request*])
- **statuses** (*list* [*Status*] | *None*)

Return type

bool

classmethod Get_status_any(*requests, status=None*)

Non-destructive test for the completion of any requests.

Parameters

- **requests** (*Sequence* [*Request*])
- **status** (*Status* | *None*)

Return type

tuple[int, bool]

classmethod Get_status_some(*requests, statuses=None*)

Non-destructive test for completion of some requests.

Parameters

- **requests** (*Sequence* [*Request*])
- **statuses** (*list* [*Status*] | *None*)

Return type

list[int] | None

Test(*status=None*)

Test for the completion of a non-blocking operation.

Parameters

status (*Status* | *None*)

Return type

bool

classmethod Testall(*requests, statuses=None*)

Test for completion of all previously initiated requests.

Parameters

- **requests** (*Sequence*[*Request*])
- **statuses** (*list*[*Status*] | *None*)

Return type

bool

classmethod Testany(*requests, status=None*)

Test for completion of any previously initiated request.

Parameters

- **requests** (*Sequence*[*Request*])
- **status** (*Status* | *None*)

Return type

tuple[*int*, *bool*]

classmethod Testsome(*requests, statuses=None*)

Test for completion of some previously initiated requests.

Parameters

- **requests** (*Sequence*[*Request*])
- **statuses** (*list*[*Status*] | *None*)

Return type

list[*int*] | *None*

Wait(*status=None*)

Wait for a non-blocking operation to complete.

Parameters

status (*Status* | *None*)

Return type

Literal[*True*]

classmethod Waitall(*requests, statuses=None*)

Wait for all previously initiated requests to complete.

Parameters

- **requests** (*Sequence*[*Request*])
- **statuses** (*list*[*Status*] | *None*)

Return type

Literal[*True*]

classmethod Waitany(*requests*, *status=None*)
Wait for any previously initiated request to complete.

Parameters

- **requests** (*Sequence*[*Request*])
- **status** (*Status* | *None*)

Return type

int

classmethod Waitosome(*requests*, *statuses=None*)

Wait for some previously initiated requests to complete.

Parameters

- **requests** (*Sequence*[*Request*])
- **statuses** (*list*[*Status*] | *None*)

Return type

list[*int*] | *None*

cancel()

Cancel a request.

Return type

None

classmethod f2py(*arg*)

Parameters

arg (*int*)

Return type

Request

free()

Call *Free* if not null.

Return type

None

classmethod fromhandle(*handle*)

Create object from MPI handle.

Parameters

handle (*int*)

Return type

Request

classmethod fromint(*arg*, /)

Translate integer handle to object.

Parameters

arg (*int*)

Return type

Request

get_status(*status=None*)

Non-destructive test for the completion of a request.

Parameters

status (*Status* | *None*)

Return type

bool

classmethod get_status_all(*requests, statuses=None*)

Non-destructive test for the completion of all requests.

Parameters

- **requests** (*Sequence*[*Request*])
- **statuses** (*list*[*Status*] | *None*)

Return type

bool

classmethod get_status_any(*requests, status=None*)

Non-destructive test for the completion of any requests.

Parameters

- **requests** (*Sequence*[*Request*])
- **status** (*Status* | *None*)

Return type

tuple[*int*, *bool*]

classmethod get_status_some(*requests, statuses=None*)

Non-destructive test for completion of some requests.

Parameters

- **requests** (*Sequence*[*Request*])
- **statuses** (*list*[*Status*] | *None*)

Return type

list[*int*] | *None*

py2f()

Return type

int

test(*status=None*)

Test for the completion of a non-blocking operation.

Parameters

status (*Status* | *None*)

Return type

tuple[*bool*, *Any* | *None*]

classmethod testall(*requests, statuses=None*)

Test for completion of all previously initiated requests.

Parameters

- **requests** (*Sequence*[*Request*])

- **statuses** (*list*[*Status*] | *None*)

Return type

tuple[*bool*, *list*[*Any*] | *None*]

classmethod **testany**(*requests*, *status=None*)

Test for completion of any previously initiated request.

Parameters

- **requests** (*Sequence*[*Request*])
- **status** (*Status* | *None*)

Return type

tuple[*int*, *bool*, *Any* | *None*]

classmethod **testsome**(*requests*, *statuses=None*)

Test for completion of some previously initiated requests.

Parameters

- **requests** (*Sequence*[*Request*])
- **statuses** (*list*[*Status*] | *None*)

Return type

tuple[*list*[*int*] | *None*, *list*[*Any*] | *None*]

toint()

Translate object to integer handle.

Return type

int

wait(*status=None*)

Wait for a non-blocking operation to complete.

Parameters

status (*Status* | *None*)

Return type

Any

classmethod **waitall**(*requests*, *statuses=None*)

Wait for all previously initiated requests to complete.

Parameters

- **requests** (*Sequence*[*Request*])
- **statuses** (*list*[*Status*] | *None*)

Return type

list[*Any*]

classmethod **waitany**(*requests*, *status=None*)

Wait for any previously initiated request to complete.

Parameters

- **requests** (*Sequence*[*Request*])
- **status** (*Status* | *None*)

Return type
tuple[int, Any]

classmethod `waitstome(requests, statuses=None)`

Wait for some previously initiated requests to complete.

Parameters

- **requests** (*Sequence*[Request])
- **statuses** (*list*[Status] | None)

Return type
tuple[list[int] | None, list[Any] | None]

Attributes Documentation

handle

MPI handle.

mpi4py.MPI.Session

class `mpi4py.MPI.Session`

Bases: `object`

Session context.

static `__new__(cls, session=None)`

Parameters
session (*Session* | None)

Return type
Self

Methods Summary

<code>Attach_buffer(buf)</code>	Attach a user-provided buffer for sending in buffered mode.
<code>Call_errhandler(errorcode)</code>	Call the error handler installed on a session.
<code>Create_errhandler(errhandler_fn)</code>	Create a new error handler for sessions.
<code>Create_group(pset_name)</code>	Create a new group from session and process set.
<code>Detach_buffer()</code>	Remove an existing attached buffer.
<code>Finalize()</code>	Finalize a session.
<code>Flush_buffer()</code>	Block until all buffered messages have been transmitted.
<code>Get_errhandler()</code>	Get the error handler for a session.
<code>Get_info()</code>	Return the current hints for a session.
<code>Get_nth_pset(n[, info])</code>	Name of the <i>n</i> -th process set.
<code>Get_num_psets([info])</code>	Number of available process sets.
<code>Get_pset_info(pset_name)</code>	Return the current hints for a session and process set.
<code>Iflush_buffer()</code>	Nonblocking flush for buffered messages.
<code>Init([info, errhandler])</code>	Create a new session.
<code>Set_errhandler(errhandler)</code>	Set the error handler for a session.
<code>f2py(arg)</code>	

continues on next page

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<code>free()</code>	Call <i>Finalize</i> if not null.
<code>fromhandle(handle)</code>	Create object from MPI handle.
<code>fromint(arg, /)</code>	Translate integer handle to object.
<code>py2f()</code>	
<code>toint()</code>	Translate object to integer handle.

Attributes Summary

<code>handle</code>	MPI handle.
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Methods Documentation

`Attach_buffer(buf)`

Attach a user-provided buffer for sending in buffered mode.

Parameters

buf (*Buffer* | *None*)

Return type

None

`Call_errhandler(errorcode)`

Call the error handler installed on a session.

Parameters

errorcode (*int*)

Return type

None

`classmethod Create_errhandler(errhandler_fn)`

Create a new error handler for sessions.

Parameters

errhandler_fn (*Callable*[[*Session*, *int*], *None*])

Return type

Errhandler

`Create_group(pset_name)`

Create a new group from session and process set.

Parameters

pset_name (*str*)

Return type

Group

`Detach_buffer()`

Remove an existing attached buffer.

Return type

Buffer | *None*

Finalize()

Finalize a session.

Return type

None

Flush_buffer()

Block until all buffered messages have been transmitted.

Return type

None

Get_errhandler()

Get the error handler for a session.

Return type

Errhandler

Get_info()

Return the current hints for a session.

Return type

Info

Get_nth_pset(*n*, *info=INFO_NULL*)

Name of the *n*-th process set.

Parameters

- **n** (*int*)
- **info** (*Info*)

Return type

str

Get_num_psets(*info=INFO_NULL*)

Number of available process sets.

Parameters

info (*Info*)

Return type

int

Get_pset_info(*pset_name*)

Return the current hints for a session and process set.

Parameters

pset_name (*str*)

Return type

Info

Iflush_buffer()

Nonblocking flush for buffered messages.

Return type

Request

classmethod `Init`(*info=INFO_NULL, errhandler=None*)

Create a new session.

Parameters

- **info** (`Info`)
- **errhandler** (`Errhandler` | `None`)

Return type

Self

Set_errhandler(*errhandler*)

Set the error handler for a session.

Parameters

errhandler (`Errhandler`)

Return type

`None`

classmethod `f2py`(*arg*)

Parameters

arg (`int`)

Return type

`Session`

free()

Call *Finalize* if not null.

Return type

`None`

classmethod `fromhandle`(*handle*)

Create object from MPI handle.

Parameters

handle (`int`)

Return type

`Session`

classmethod `fromint`(*arg, /*)

Translate integer handle to object.

Parameters

arg (`int`)

Return type

`Session`

py2f()

Return type

`int`

toint()

Translate object to integer handle.

Return type

`int`

Attributes Documentation

handle

MPI handle.

mpi4py.MPI.Status

class mpi4py.MPI.Status

Bases: `object`

Status object.

static `__new__(cls, status=None)`

Parameters

status (`Status` | `None`)

Return type

Self

Methods Summary

<code>Get_count([datatype])</code>	Get the number of <i>top level</i> elements.
<code>Get_elements(datatype)</code>	Get the number of basic elements in a datatype.
<code>Get_error()</code>	Get message error.
<code>Get_source()</code>	Get message source.
<code>Get_tag()</code>	Get message tag.
<code>Is_cancelled()</code>	Test to see if a request was cancelled.
<code>Set_cancelled(flag)</code>	Set the cancelled state associated with a status.
<code>Set_elements(datatype, count)</code>	Set the number of elements in a status.
<code>Set_error(error)</code>	Set message error.
<code>Set_source(source)</code>	Set message source.
<code>Set_tag(tag)</code>	Set message tag.
<code>f2py(arg)</code>	
<code>py2f()</code>	
<code>tomemory()</code>	Return status memory view.

Attributes Summary

<code>cancelled</code>	Cancelled state.
<code>count</code>	Byte count.
<code>error</code>	Message error.
<code>source</code>	Message source.
<code>tag</code>	Message tag.

Methods Documentation

Get_count (`datatype=BYTE`)

Get the number of *top level* elements.

Parameters

datatype (`Datatype`)

Return type

int

Get_elements(*datatype*)

Get the number of basic elements in a datatype.

Parameters

datatype (*Datatype*)

Return type

int

Get_error()

Get message error.

Return type

int

Get_source()

Get message source.

Return type

int

Get_tag()

Get message tag.

Return type

int

Is_cancelled()

Test to see if a request was cancelled.

Return type

bool

Set_cancelled(*flag*)

Set the cancelled state associated with a status.

Note

This method should be used only when implementing query callback functions for generalized requests.

Parameters

flag (*bool*)

Return type

None

Set_elements(*datatype, count*)

Set the number of elements in a status.

Note

This method should be only used when implementing query callback functions for generalized requests.

Parameters

- **datatype** (*Datatype*)

- **count** (*int*)

Return type

None

Set_error(*error*)

Set message error.

Parameters

error (*int*)

Return type

None

Set_source(*source*)

Set message source.

Parameters

source (*int*)

Return type

None

Set_tag(*tag*)

Set message tag.

Parameters

tag (*int*)

Return type

None

classmethod f2py(*arg*)

Parameters

arg (*list[int]*)

Return type

Self

py2f()

Return type

list[int]

tomemory()

Return status memory view.

Return type

memoryview

Attributes Documentation

cancelled

Cancelled state.

count

Byte count.

error

Message error.

source

Message source.

tag

Message tag.

mpi4py.MPI.Topocomm

class mpi4py.MPI.Topocomm

Bases: *Intracomm*

Topology intracommunicator.

static `__new__(cls, comm=None)`

Parameters

comm (*Topocomm* | *None*)

Return type

Self

Methods Summary

<i>Ineighbor_allgather</i> (sendbuf, recvbuf)	Nonblocking Neighbor Gather to All.
<i>Ineighbor_allgatherv</i> (sendbuf, recvbuf)	Nonblocking Neighbor Gather to All Vector.
<i>Ineighbor_alltoall</i> (sendbuf, recvbuf)	Nonblocking Neighbor All to All.
<i>Ineighbor_alltoallv</i> (sendbuf, recvbuf)	Nonblocking Neighbor All to All Vector.
<i>Ineighbor_alltoallw</i> (sendbuf, recvbuf)	Nonblocking Neighbor All to All General.
<i>Neighbor_allgather</i> (sendbuf, recvbuf)	Neighbor Gather to All.
<i>Neighbor_allgather_init</i> (sendbuf, recvbuf[, info])	Persistent Neighbor Gather to All.
<i>Neighbor_allgatherv</i> (sendbuf, recvbuf)	Neighbor Gather to All Vector.
<i>Neighbor_allgatherv_init</i> (sendbuf, recvbuf[, ...])	Persistent Neighbor Gather to All Vector.
<i>Neighbor_alltoall</i> (sendbuf, recvbuf)	Neighbor All to All.
<i>Neighbor_alltoall_init</i> (sendbuf, recvbuf[, info])	Persistent Neighbor All to All.
<i>Neighbor_alltoallv</i> (sendbuf, recvbuf)	Neighbor All to All Vector.
<i>Neighbor_alltoallv_init</i> (sendbuf, recvbuf[, info])	Persistent Neighbor All to All Vector.
<i>Neighbor_alltoallw</i> (sendbuf, recvbuf)	Neighbor All to All General.
<i>Neighbor_alltoallw_init</i> (sendbuf, recvbuf[, info])	Persistent Neighbor All to All General.
<i>neighbor_allgather</i> (sendobj)	Neighbor Gather to All.
<i>neighbor_alltoall</i> (sendobj)	Neighbor All to All.

Attributes Summary

<i>degrees</i>	Number of incoming and outgoing neighbors.
<i>indegree</i>	Number of incoming neighbors.

continues on next page

Table 55 – continued from previous page

<i>inedges</i>	Incoming neighbors.
<i>inoutedges</i>	Incoming and outgoing neighbors.
<i>outdegree</i>	Number of outgoing neighbors.
<i>outedges</i>	Outgoing neighbors.

Methods Documentation

Ineighbor_allgather(*sendbuf*, *recvbuf*)

Nonblocking Neighbor Gather to All.

Parameters

- **sendbuf** (BufSpec)
- **recvbuf** (BufSpecB)

Return type

Request

Ineighbor_allgatherv(*sendbuf*, *recvbuf*)

Nonblocking Neighbor Gather to All Vector.

Parameters

- **sendbuf** (BufSpec)
- **recvbuf** (BufSpecV)

Return type

Request

Ineighbor_alltoall(*sendbuf*, *recvbuf*)

Nonblocking Neighbor All to All.

Parameters

- **sendbuf** (BufSpecB)
- **recvbuf** (BufSpecB)

Return type

Request

Ineighbor_alltoallv(*sendbuf*, *recvbuf*)

Nonblocking Neighbor All to All Vector.

Parameters

- **sendbuf** (BufSpecV)
- **recvbuf** (BufSpecV)

Return type

Request

Ineighbor_alltoallw(*sendbuf*, *recvbuf*)

Nonblocking Neighbor All to All General.

Parameters

- **sendbuf** (BufSpecW)
- **recvbuf** (BufSpecW)

Return type

Request

Neighbor_allgather(*sendbuf*, *recvbuf*)

Neighbor Gather to All.

Parameters

- **sendbuf** (BufSpec)
- **recvbuf** (BufSpecB)

Return type

None

Neighbor_allgather_init(*sendbuf*, *recvbuf*, *info=INFO_NULL*)

Persistent Neighbor Gather to All.

Parameters

- **sendbuf** (BufSpec)
- **recvbuf** (BufSpecB)
- **info** (Info)

Return type

Prequest

Neighbor_allgatherv(*sendbuf*, *recvbuf*)

Neighbor Gather to All Vector.

Parameters

- **sendbuf** (BufSpec)
- **recvbuf** (BufSpecV)

Return type

None

Neighbor_allgatherv_init(*sendbuf*, *recvbuf*, *info=INFO_NULL*)

Persistent Neighbor Gather to All Vector.

Parameters

- **sendbuf** (BufSpec)
- **recvbuf** (BufSpecV)
- **info** (Info)

Return type

Prequest

Neighbor_alltoall(*sendbuf*, *recvbuf*)

Neighbor All to All.

Parameters

- **sendbuf** (BufSpecB)
- **recvbuf** (BufSpecB)

Return type

None

Neighbor_alltoall_init(*sendbuf*, *recvbuf*, *info=INFO_NULL*)

Persistent Neighbor All to All.

Parameters

- **sendbuf** (BufSpecB)
- **recvbuf** (BufSpecB)
- **info** (Info)

Return type

Prequest

Neighbor_alltoallv(*sendbuf*, *recvbuf*)

Neighbor All to All Vector.

Parameters

- **sendbuf** (BufSpecV)
- **recvbuf** (BufSpecV)

Return type

None

Neighbor_alltoallv_init(*sendbuf*, *recvbuf*, *info=INFO_NULL*)

Persistent Neighbor All to All Vector.

Parameters

- **sendbuf** (BufSpecV)
- **recvbuf** (BufSpecV)
- **info** (Info)

Return type

Prequest

Neighbor_alltoallw(*sendbuf*, *recvbuf*)

Neighbor All to All General.

Parameters

- **sendbuf** (BufSpecW)
- **recvbuf** (BufSpecW)

Return type

None

Neighbor_alltoallw_init(*sendbuf*, *recvbuf*, *info=INFO_NULL*)

Persistent Neighbor All to All General.

Parameters

- **sendbuf** (BufSpecW)
- **recvbuf** (BufSpecW)
- **info** (Info)

Return type

Prequest

neighbor_allgather(*sendobj*)

Neighbor Gather to All.

Parameters

sendobj (*Any*)

Return type

list[Any]

neighbor_alltoall(*sendobj*)

Neighbor All to All.

Parameters

sendobj (*list[Any]*)

Return type

list[Any]

Attributes Documentation

degrees

Number of incoming and outgoing neighbors.

indegree

Number of incoming neighbors.

inedges

Incoming neighbors.

inoutedges

Incoming and outgoing neighbors.

outdegree

Number of outgoing neighbors.

outedges

Outgoing neighbors.

mpi4py.MPI.Win

class `mpi4py.MPI.Win`

Bases: `object`

Remote memory access context.

static `__new__(cls, win=None)`

Parameters

win (`Win` | `None`)

Return type

Self

Methods Summary

`Accumulate`(`origin`, `target_rank`[, `target`, `op`])

Accumulate data into the target process.

continues on next page

Table 56 – continued from previous page

<i>Allocate</i> (size[, disp_unit, info, comm])	Create an window object for one-sided communication.
<i>Allocate_shared</i> (size[, disp_unit, info, comm])	Create an window object for one-sided communication.
<i>Attach</i> (memory)	Attach a local memory region.
<i>Call_errhandler</i> (errorcode)	Call the error handler installed on a window.
<i>Compare_and_swap</i> (origin, compare, result, ...)	Perform one-sided atomic compare-and-swap.
<i>Complete</i> ()	Complete an RMA operation begun after an <i>Start</i> .
<i>Create</i> (memory[, disp_unit, info, comm])	Create an window object for one-sided communication.
<i>Create_dynamic</i> ([info, comm])	Create an window object for one-sided communication.
<i>Create_errhandler</i> (errhandler_fn)	Create a new error handler for windows.
<i>Create_keyval</i> ([copy_fn, delete_fn, nopython])	Create a new attribute key for windows.
<i>Delete_attr</i> (keyval)	Delete attribute value associated with a key.
<i>Detach</i> (memory)	Detach a local memory region.
<i>Fence</i> ([assertion])	Perform an MPI fence synchronization on a window.
<i>Fetch_and_op</i> (origin, result, target_rank[, ...])	Perform one-sided read-modify-write.
<i>Flush</i> (rank)	Complete all outstanding RMA operations at a target.
<i>Flush_all</i> ()	Complete all outstanding RMA operations at all targets.
<i>Flush_local</i> (rank)	Complete locally all outstanding RMA operations at a target.
<i>Flush_local_all</i> ()	Complete locally all outstanding RMA operations at all targets.
<i>Free</i> ()	Free a window.
<i>Free_keyval</i> (keyval)	Free an attribute key for windows.
<i>Get</i> (origin, target_rank[, target])	Get data from a memory window on a remote process.
<i>Get_accumulate</i> (origin, result, target_rank)	Fetch-and-accumulate data into the target process.
<i>Get_attr</i> (keyval)	Retrieve attribute value by key.
<i>Get_errhandler</i> ()	Get the error handler for a window.
<i>Get_group</i> ()	Access the group of processes that created the window.
<i>Get_info</i> ()	Return the current hints for a window.
<i>Get_name</i> ()	Get the print name for this window.
<i>Lock</i> (rank[, lock_type, assertion])	Begin an RMA access epoch at the target process.
<i>Lock_all</i> ([assertion])	Begin an RMA access epoch at all processes.
<i>Post</i> (group[, assertion])	Start an RMA exposure epoch.
<i>Put</i> (origin, target_rank[, target])	Put data into a memory window on a remote process.
<i>Raccumulate</i> (origin, target_rank[, target, op])	Fetch-and-accumulate data into the target process.
<i>Rget</i> (origin, target_rank[, target])	Get data from a memory window on a remote process.
<i>Rget_accumulate</i> (origin, result, target_rank)	Accumulate data into the target process using remote memory access.
<i>Rput</i> (origin, target_rank[, target])	Put data into a memory window on a remote process.
<i>Set_attr</i> (keyval, attrval)	Store attribute value associated with a key.
<i>Set_errhandler</i> (errhandler)	Set the error handler for a window.
<i>Set_info</i> (info)	Set new values for the hints associated with a window.
<i>Set_name</i> (name)	Set the print name for this window.
<i>Shared_query</i> (rank)	Query the process-local address for remote memory segments.
<i>Start</i> (group[, assertion])	Start an RMA access epoch for MPI.
<i>Sync</i> ()	Synchronize public and private copies of the window.

continues on next page

Table 56 – continued from previous page

<code>Test()</code>	Test whether an RMA exposure epoch has completed.
<code>Unlock(rank)</code>	Complete an RMA access epoch at the target process.
<code>Unlock_all()</code>	Complete an RMA access epoch at all processes.
<code>Wait()</code>	Complete an RMA exposure epoch begun with <i>Post</i> .
<code>f2py(arg)</code>	
<code>free()</code>	Call <i>Free</i> if not null.
<code>fromhandle(handle)</code>	Create object from MPI handle.
<code>fromint(arg, /)</code>	Translate integer handle to object.
<code>py2f()</code>	
<code>toint()</code>	Translate object to integer handle.
<code>tomemory()</code>	Return window memory buffer.

Attributes Summary

<code>attrs</code>	Attributes.
<code>flavor</code>	Create flavor.
<code>group</code>	Group.
<code>group_rank</code>	Group rank.
<code>group_size</code>	Group size.
<code>handle</code>	MPI handle.
<code>info</code>	Info hints.
<code>model</code>	Memory model.
<code>name</code>	Print name.

Methods Documentation

Accumulate(*origin*, *target_rank*, *target=None*, *op=SUM*)

Accumulate data into the target process.

Parameters

- **origin** (*BufSpec*)
- **target_rank** (*int*)
- **target** (*TargetSpec* | *None*)
- **op** (*Op*)

Return type

None

classmethod Allocate(*size*, *disp_unit=1*, *info=INFO_NULL*, *comm=COMM_SELF*)

Create an window object for one-sided communication.

Parameters

- **size** (*int*)
- **disp_unit** (*int*)
- **info** (*Info*)
- **comm** (*Intracomm*)

Return type*Self***classmethod Allocate_shared**(*size, disp_unit=1, info=INFO_NULL, comm=COMM_SELF*)

Create an window object for one-sided communication.

Parameters

- **size** (*int*)
- **disp_unit** (*int*)
- **info** (*Info*)
- **comm** (*Intracomm*)

Return type*Self***Attach**(*memory*)

Attach a local memory region.

Parameters**memory** (*Buffer*)**Return type***None***Call_errhandler**(*errorcode*)

Call the error handler installed on a window.

Parameters**errorcode** (*int*)**Return type***None***Compare_and_swap**(*origin, compare, result, target_rank, target_disp=0*)

Perform one-sided atomic compare-and-swap.

Parameters

- **origin** (*BufSpec*)
- **compare** (*BufSpec*)
- **result** (*BufSpec*)
- **target_rank** (*int*)
- **target_disp** (*int*)

Return type*None***Complete**()Complete an RMA operation begun after an *Start*.**Return type***None***classmethod Create**(*memory, disp_unit=1, info=INFO_NULL, comm=COMM_SELF*)

Create an window object for one-sided communication.

Parameters

- **memory** (*Buffer* | *Bottom*)
- **disp_unit** (*int*)
- **info** (*Info*)
- **comm** (*Intracomm*)

Return type
Self

classmethod **Create_dynamic**(*info=INFO_NULL, comm=COMM_SELF*)

Create an window object for one-sided communication.

Parameters

- **info** (*Info*)
- **comm** (*Intracomm*)

Return type
Self

classmethod **Create_errhandler**(*errhandler_fn*)

Create a new error handler for windows.

Parameters

errhandler_fn (*Callable*[[*Win, int*], *None*])

Return type
Errhandler

classmethod **Create_keyval**(*copy_fn=None, delete_fn=None, nopython=False*)

Create a new attribute key for windows.

Parameters

- **copy_fn** (*Callable*[[*Win, int, Any*], *Any*] | *None*)
- **delete_fn** (*Callable*[[*Win, int, Any*], *None*] | *None*)
- **nopython** (*bool*)

Return type
int

Delete_attr(*keyval*)

Delete attribute value associated with a key.

Parameters

keyval (*int*)

Return type
None

Detach(*memory*)

Detach a local memory region.

Parameters

memory (*Buffer*)

Return type
None

Fence(*assertion=0*)

Perform an MPI fence synchronization on a window.

Parameters

assertion (*int*)

Return type

None

Fetch_and_op(*origin, result, target_rank, target_disp=0, op=SUM*)

Perform one-sided read-modify-write.

Parameters

- **origin** (BufSpec)
- **result** (BufSpec)
- **target_rank** (*int*)
- **target_disp** (*int*)
- **op** (*Op*)

Return type

None

Flush(*rank*)

Complete all outstanding RMA operations at a target.

Parameters

rank (*int*)

Return type

None

Flush_all()

Complete all outstanding RMA operations at all targets.

Return type

None

Flush_local(*rank*)

Complete locally all outstanding RMA operations at a target.

Parameters

rank (*int*)

Return type

None

Flush_local_all()

Complete locally all outstanding RMA operations at all targets.

Return type

None

Free()

Free a window.

Return type

None

classmethod **Free_keyval**(*keyval*)

Free an attribute key for windows.

Parameters

keyval (*int*)

Return type

int

Get(*origin*, *target_rank*, *target=None*)

Get data from a memory window on a remote process.

Parameters

- **origin** (*BufSpec*)
- **target_rank** (*int*)
- **target** (*TargetSpec* | *None*)

Return type

None

Get_accumulate(*origin*, *result*, *target_rank*, *target=None*, *op=SUM*)

Fetch-and-accumulate data into the target process.

Parameters

- **origin** (*BufSpec*)
- **result** (*BufSpec*)
- **target_rank** (*int*)
- **target** (*TargetSpec* | *None*)
- **op** (*Op*)

Return type

None

Get_attr(*keyval*)

Retrieve attribute value by key.

Parameters

keyval (*int*)

Return type

int | *Any* | *None*

Get_errhandler()

Get the error handler for a window.

Return type

Errhandler

Get_group()

Access the group of processes that created the window.

Return type

Group

Get_info()

Return the current hints for a window.

Return type

Info

Get_name()

Get the print name for this window.

Return type

str

Lock(rank, lock_type=LOCK_EXCLUSIVE, assertion=0)

Begin an RMA access epoch at the target process.

Parameters

- **rank** (*int*)
- **lock_type** (*int*)
- **assertion** (*int*)

Return type

None

Lock_all(assertion=0)

Begin an RMA access epoch at all processes.

Parameters

- **assertion** (*int*)

Return type

None

Post(group, assertion=0)

Start an RMA exposure epoch.

Parameters

- **group** (*Group*)
- **assertion** (*int*)

Return type

None

Put(origin, target_rank, target=None)

Put data into a memory window on a remote process.

Parameters

- **origin** (*BufSpec*)
- **target_rank** (*int*)
- **target** (*TargetSpec* | *None*)

Return type

None

Raccumulate(origin, target_rank, target=None, op=SUM)

Fetch-and-accumulate data into the target process.

Parameters

- **origin** (BufSpec)
- **target_rank** (*int*)
- **target** (TargetSpec | *None*)
- **op** (Op)

Return type

Request

Rget(*origin, target_rank, target=None*)

Get data from a memory window on a remote process.

Parameters

- **origin** (BufSpec)
- **target_rank** (*int*)
- **target** (TargetSpec | *None*)

Return type

Request

Rget_accumulate(*origin, result, target_rank, target=None, op=SUM*)

Accumulate data into the target process using remote memory access.

Parameters

- **origin** (BufSpec)
- **result** (BufSpec)
- **target_rank** (*int*)
- **target** (TargetSpec | *None*)
- **op** (Op)

Return type

Request

Rput(*origin, target_rank, target=None*)

Put data into a memory window on a remote process.

Parameters

- **origin** (BufSpec)
- **target_rank** (*int*)
- **target** (TargetSpec | *None*)

Return type

Request

Set_attr(*keyval, attrval*)

Store attribute value associated with a key.

Parameters

- **keyval** (*int*)
- **attrval** (*Any*)

Return type

None

Set_errhandler(*errhandler*)

Set the error handler for a window.

Parameters

errhandler (*Errhandler*)

Return type

None

Set_info(*info*)

Set new values for the hints associated with a window.

Parameters

info (*Info*)

Return type

None

Set_name(*name*)

Set the print name for this window.

Parameters

name (*str*)

Return type

None

Shared_query(*rank*)

Query the process-local address for remote memory segments.

Parameters

rank (*int*)

Return type

tuple[buffer, int]

Start(*group*, *assertion=0*)

Start an RMA access epoch for MPI.

Parameters

- **group** (*Group*)
- **assertion** (*int*)

Return type

None

Sync()

Synchronize public and private copies of the window.

Return type

None

Test()

Test whether an RMA exposure epoch has completed.

Return type

bool

Unlock(*rank*)

Complete an RMA access epoch at the target process.

Parameters

rank (*int*)

Return type

None

Unlock_all()

Complete an RMA access epoch at all processes.

Return type

None

Wait()

Complete an RMA exposure epoch begun with *Post*.

Return type

Literal[True]

classmethod f2py(*arg*)

Parameters

arg (*int*)

Return type

Win

free()

Call *Free* if not null.

Return type

None

classmethod fromhandle(*handle*)

Create object from MPI handle.

Parameters

handle (*int*)

Return type

Win

classmethod fromint(*arg*, /)

Translate integer handle to object.

Parameters

arg (*int*)

Return type

Win

py2f()

Return type

int

toint()

Translate object to integer handle.

Return type

int

tomemory()

Return window memory buffer.

Return type

buffer

Attributes Documentation

attrs

Attributes.

flavor

Create flavor.

group

Group.

group_rank

Group rank.

group_size

Group size.

handle

MPI handle.

info

Info hints.

model

Memory model.

name

Print name.

mpi4py.MPI.buffer

class mpi4py.MPI.buffer

Bases: `object`

Buffer.

static `__new__(cls, buf, /)`

Parameters

buf (`Buffer`)

Return type

Self

Methods Summary

<code>allocate</code> (nbytes[, clear])	Buffer allocation.
<code>cast</code> (format[, shape])	Cast to a <code>memoryview</code> with new format or shape.
<code>fromaddress</code> (address, nbytes[, readonly])	Buffer from address and size in bytes.
<code>frombuffer</code> (obj[, readonly])	Buffer from buffer-like object.

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<code>release()</code>	Release the underlying buffer exposed by the buffer object.
<code>tobytes([order])</code>	Return the data in the buffer as a byte string.
<code>toreadonly()</code>	Return a readonly version of the buffer object.

Attributes Summary

<code>address</code>	Buffer address.
<code>format</code>	Format of each element.
<code>itemsize</code>	Size (in bytes) of each element.
<code>nbytes</code>	Buffer size (in bytes).
<code>obj</code>	Object exposing buffer.
<code>readonly</code>	Buffer is read-only.

Methods Documentation

static `allocate(nbytes, clear=False)`

Buffer allocation.

Parameters

- `nbytes` (*int*)
- `clear` (*bool*)

Return type

`buffer`

cast(*format*, *shape=Ellipsis*)

Cast to a `memoryview` with new format or shape.

Parameters

- `format` (*str*)
- `shape` (*list[int] | tuple[int, ...]*)

Return type

`memoryview`

static `fromaddress(address, nbytes, readonly=False)`

Buffer from address and size in bytes.

Parameters

- `address` (*int*)
- `nbytes` (*int*)
- `readonly` (*bool*)

Return type

`buffer`

static `frombuffer(obj, readonly=False)`

Buffer from buffer-like object.

Parameters

- **obj** (*Buffer*)
- **readonly** (*bool*)

Return type
buffer

release()

Release the underlying buffer exposed by the buffer object.

Return type
None

tobytes (*order=None*)

Return the data in the buffer as a byte string.

Parameters
order (*str* | *None*)

Return type
bytes

toreadonly()

Return a readonly version of the buffer object.

Return type
buffer

Attributes Documentation

address

Buffer address.

format

Format of each element.

itemsize

Size (in bytes) of each element.

nbytes

Buffer size (in bytes).

obj

Object exposing buffer.

readonly

Buffer is read-only.

mpi4py.MPI.memory

mpi4py.MPI.**memory**

alias of *buffer*

Exceptions

Exception

Exception class.

mpi4py.MPI.Exception

exception mpi4py.MPI.Exception

Bases: RuntimeError

Exception class.

`__init__(ierr=SUCCESS, /)`

Parameters

ierr (*int*)

Return type

None

Methods Summary

<code>Get_error_class()</code>	Error class.
<code>Get_error_code()</code>	Error code.
<code>Get_error_string()</code>	Error string.

Attributes Summary

<code>error_class</code>	Error class.
<code>error_code</code>	Error code.
<code>error_string</code>	Error string.

Methods Documentation

Get_error_class()

Error class.

Return type

int

Get_error_code()

Error code.

Return type

int

Get_error_string()

Error string.

Return type

str

Attributes Documentation

error_class

Error class.

error_code

Error code.

error_string

Error string.

Functions

<code>Add_error_class()</code>	Add an <i>error class</i> to the known error classes.
<code>Add_error_code(errorclass)</code>	Add an <i>error code</i> to an <i>error class</i> .
<code>Add_error_string(errorcode, string)</code>	Associate an <i>error string</i> with an <i>error class</i> or <i>error code</i> .
<code>Aint_add(base, disp)</code>	Return the sum of base address and displacement.
<code>Aint_diff(addr1, addr2)</code>	Return the difference between absolute addresses.
<code>Alloc_mem(size[, info])</code>	Allocate memory for message passing and remote memory access.
<code>Attach_buffer(buf)</code>	Attach a user-provided buffer for sending in buffered mode.
<code>Close_port(port_name)</code>	Close a port.
<code>Compute_dims(nnodes, dims)</code>	Return a balanced distribution of processes per coordinate direction.
<code>Detach_buffer()</code>	Remove an existing attached buffer.
<code>Finalize()</code>	Terminate the MPI execution environment.
<code>Flush_buffer()</code>	Block until all buffered messages have been transmitted.
<code>Free_mem(mem)</code>	Free memory allocated with <i>Alloc_mem</i> .
<code>Get_abi_fortran_info()</code>	Obtain information about the Fortran MPI ABI.
<code>Get_abi_info()</code>	Obtain information about the MPI ABI.
<code>Get_abi_version()</code>	Obtain the MPI ABI version number.
<code>Get_address(location)</code>	Get the address of a location in memory.
<code>Get_error_class(errorcode)</code>	Convert an <i>error code</i> into an <i>error class</i> .
<code>Get_error_string(errorcode)</code>	Return the <i>error string</i> for a given <i>error class</i> or <i>error code</i> .
<code>Get_hw_resource_info()</code>	Obtain information about the hardware platform of the calling processor.
<code>Get_library_version()</code>	Obtain the version string of the MPI library.
<code>Get_processor_name()</code>	Obtain the name of the calling processor.
<code>Get_version()</code>	Obtain the version number of the MPI standard.
<code>Iflush_buffer()</code>	Nonblocking flush for buffered messages.
<code>Init()</code>	Initialize the MPI execution environment.
<code>Init_thread([required])</code>	Initialize the MPI execution environment.
<code>Is_finalized()</code>	Indicate whether <i>Finalize</i> has completed.
<code>Is_initialized()</code>	Indicate whether <i>Init</i> has been called.
<code>Is_thread_main()</code>	Indicate whether this thread called <i>Init</i> or <i>Init_thread</i> .
<code>Lookup_name(service_name[, info])</code>	Lookup a port name given a service name.
<code>Open_port([info])</code>	Return an address used to connect group of processes.
<code>Pcontrol(level)</code>	Control profiling.
<code>Publish_name(service_name, port_name[, info])</code>	Publish a service name.
<code>Query_thread()</code>	Return the level of thread support provided by the MPI library.
<code>Register_datarep(datarep, read_fn, write_fn, ...)</code>	Register user-defined data representations.
<code>Remove_error_class(errorclass)</code>	Remove an <i>error class</i> from the known error classes.
<code>Remove_error_code(errorcode)</code>	Remove an <i>error code</i> from the known error codes.
<code>Remove_error_string(errorcode)</code>	Remove <i>error string</i> association from <i>error class</i> or <i>error code</i> .
<code>Unpublish_name(service_name, port_name[, info])</code>	Unpublish a service name.
<code>Wtick()</code>	Return the resolution of <i>Wtime</i> .
<code>Wtime()</code>	Return an elapsed time on the calling processor.

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mpi4py.MPI.Add_error_class`mpi4py.MPI.Add_error_class()`Add an *error class* to the known error classes.**Return type**`int`**mpi4py.MPI.Add_error_code**`mpi4py.MPI.Add_error_code(errorclass)`Add an *error code* to an *error class*.**Parameters****errorclass** (`int`)**Return type**`int`**mpi4py.MPI.Add_error_string**`mpi4py.MPI.Add_error_string(errorcode, string)`Associate an *error string* with an *error class* or *error code*.**Parameters**

- **errorcode** (`int`)
- **string** (`str`)

Return type`None`**mpi4py.MPI.Aint_add**`mpi4py.MPI.Aint_add(base, disp)`

Return the sum of base address and displacement.

Parameters

- **base** (`int`)
- **disp** (`int`)

Return type`int`**mpi4py.MPI.Aint_diff**`mpi4py.MPI.Aint_diff(addr1, addr2)`

Return the difference between absolute addresses.

Parameters

- **addr1** (`int`)
- **addr2** (`int`)

Return type

`int`

mpi4py.MPI.Alloc_mem

`mpi4py.MPI.Alloc_mem(size, info=INFO_NULL)`

Allocate memory for message passing and remote memory access.

Parameters

- **size** (`int`)
- **info** (`Info`)

Return type

`buffer`

mpi4py.MPI.Attach_buffer

`mpi4py.MPI.Attach_buffer(buf)`

Attach a user-provided buffer for sending in buffered mode.

Parameters

buf (`Buffer` | `None`)

Return type

`None`

mpi4py.MPI.Close_port

`mpi4py.MPI.Close_port(port_name)`

Close a port.

Parameters

port_name (`str`)

Return type

`None`

mpi4py.MPI.Compute_dims

`mpi4py.MPI.Compute_dims(nnodes, dims)`

Return a balanced distribution of processes per coordinate direction.

Parameters

- **nnodes** (`int`)
- **dims** (`int` | `Sequence[int]`)

Return type

`list[int]`

mpi4py.MPI.Detach_buffer

`mpi4py.MPI.Detach_buffer()`

Remove an existing attached buffer.

Return type

`Buffer` | `None`

mpi4py.MPI.Finalize

`mpi4py.MPI.Finalize()`

Terminate the MPI execution environment.

Return type

None

mpi4py.MPI.Flush_buffer

`mpi4py.MPI.Flush_buffer()`

Block until all buffered messages have been transmitted.

Return type

None

mpi4py.MPI.Free_mem

`mpi4py.MPI.Free_mem(mem)`

Free memory allocated with *Alloc_mem*.

Parameters

mem (buffer)

Return type

None

mpi4py.MPI.Get_abi_fortran_info

`mpi4py.MPI.Get_abi_fortran_info()`

Obtain information about the Fortran MPI ABI.

Return type

Info

mpi4py.MPI.Get_abi_info

`mpi4py.MPI.Get_abi_info()`

Obtain information about the MPI ABI.

Return type

Info

mpi4py.MPI.Get_abi_version

`mpi4py.MPI.Get_abi_version()`

Obtain the MPI ABI version number.

Return type

tuple[int, int]

mpi4py.MPI.Get_address

`mpi4py.MPI.Get_address(location)`

Get the address of a location in memory.

Parameters

location (Buffer / Bottom)

Return type

int

mpi4py.MPI.Get_error_class

`mpi4py.MPI.Get_error_class(errorcode)`

Convert an *error code* into an *error class*.

Parameters

errorcode (*int*)

Return type

int

mpi4py.MPI.Get_error_string

`mpi4py.MPI.Get_error_string(errorcode)`

Return the *error string* for a given *error class* or *error code*.

Parameters

errorcode (*int*)

Return type

str

mpi4py.MPI.Get_hw_resource_info

`mpi4py.MPI.Get_hw_resource_info()`

Obtain information about the hardware platform of the calling processor.

Return type

Info

mpi4py.MPI.Get_library_version

`mpi4py.MPI.Get_library_version()`

Obtain the version string of the MPI library.

Return type

str

mpi4py.MPI.Get_processor_name

`mpi4py.MPI.Get_processor_name()`

Obtain the name of the calling processor.

Return type

str

mpi4py.MPI.Get_version

`mpi4py.MPI.Get_version()`

Obtain the version number of the MPI standard.

Return type

tuple[int, int]

mpi4py.MPI.Iflush_buffer

`mpi4py.MPI.Iflush_buffer()`

Nonblocking flush for buffered messages.

Return type

Request

mpi4py.MPI.Init

`mpi4py.MPI.Init()`

Initialize the MPI execution environment.

Return type

None

mpi4py.MPI.Init_thread

`mpi4py.MPI.Init_thread(required=THREAD_MULTIPLE)`

Initialize the MPI execution environment.

Parameters

required (*int*)

Return type

int

mpi4py.MPI.Is_finalized

`mpi4py.MPI.Is_finalized()`

Indicate whether *Finalize* has completed.

Return type

bool

mpi4py.MPI.Is_initialized

`mpi4py.MPI.Is_initialized()`

Indicate whether *Init* has been called.

Return type

bool

mpi4py.MPI.Is_thread_main

`mpi4py.MPI.Is_thread_main()`

Indicate whether this thread called *Init* or *Init_thread*.

Return type

bool

mpi4py.MPI.Lookup_name

`mpi4py.MPI.Lookup_name(service_name, info=INFO_NULL)`

Lookup a port name given a service name.

Parameters

- **service_name** (*str*)

- **info** (*Info*)

Return type

str

mpi4py.MPI.Open_port

`mpi4py.MPI.Open_port(info=INFO_NULL)`

Return an address used to connect group of processes.

Parameters

- **info** (*Info*)

Return type

str

mpi4py.MPI.Pcontrol

`mpi4py.MPI.Pcontrol(level)`

Control profiling.

Parameters

- **level** (*int*)

Return type

None

mpi4py.MPI.Publish_name

`mpi4py.MPI.Publish_name(service_name, port_name, info=INFO_NULL)`

Publish a service name.

Parameters

- **service_name** (*str*)
- **port_name** (*str*)
- **info** (*Info*)

Return type

None

mpi4py.MPI.Query_thread

`mpi4py.MPI.Query_thread()`

Return the level of thread support provided by the MPI library.

Return type

int

mpi4py.MPI.Register_datarep

`mpi4py.MPI.Register_datarep(datarep, read_fn, write_fn, extent_fn)`

Register user-defined data representations.

Parameters

- **datarep** (*str*)
- **read_fn** (*Callable[[Buffer, Datatype, int, Buffer, int], None]*)

- `write_fn(Callable[[Buffer, Datatype, int, Buffer, int], None])`
- `extent_fn(Callable[[Datatype], int])`

Return type

None

mpi4py.MPI.Remove_error_class

`mpi4py.MPI.Remove_error_class(errorclass)`

Remove an *error class* from the known error classes.

Parameters

`errorclass (int)`

Return type

None

mpi4py.MPI.Remove_error_code

`mpi4py.MPI.Remove_error_code(errorcode)`

Remove an *error code* from the known error codes.

Parameters

`errorcode (int)`

Return type

None

mpi4py.MPI.Remove_error_string

`mpi4py.MPI.Remove_error_string(errorcode)`

Remove *error string* association from *error class* or *error code*.

Parameters

`errorcode (int)`

Return type

None

mpi4py.MPI.Unpublish_name

`mpi4py.MPI.Unpublish_name(service_name, port_name, info=INFO_NULL)`

Unpublish a service name.

Parameters

- `service_name (str)`
- `port_name (str)`
- `info (Info)`

Return type

None

mpi4py.MPI.Wtick

`mpi4py.MPI.Wtick()`

Return the resolution of *Wtime*.

Return type

float

mpi4py.MPI.Wtime

`mpi4py.MPI.Wtime()`

Return an elapsed time on the calling processor.

Return type

float

mpi4py.MPI.get_vendor

`mpi4py.MPI.get_vendor()`

Information about the underlying MPI implementation.

Returns

- string with the name of the MPI implementation.
- integer 3-tuple version number (major, minor, micro).

Return type

tuple[str, tuple[int, int, int]]

Attributes

<i>UNDEFINED</i>	Constant UNDEFINED of type <code>int</code>
<i>ANY_SOURCE</i>	Constant ANY_SOURCE of type <code>int</code>
<i>ANY_TAG</i>	Constant ANY_TAG of type <code>int</code>
<i>PROC_NULL</i>	Constant PROC_NULL of type <code>int</code>
<i>ROOT</i>	Constant ROOT of type <code>int</code>
<i>KEYVAL_INVALID</i>	Constant KEYVAL_INVALID of type <code>int</code>
<i>TAG_UB</i>	Constant TAG_UB of type <code>int</code>
<i>IO</i>	Constant IO of type <code>int</code>
<i>WTIME_IS_GLOBAL</i>	Constant WTIME_IS_GLOBAL of type <code>int</code>
<i>UNIVERSE_SIZE</i>	Constant UNIVERSE_SIZE of type <code>int</code>
<i>APPNUM</i>	Constant APPNUM of type <code>int</code>
<i>LASTUSED</i>	Constant LASTUSED of type <code>int</code>
<i>WIN_BASE</i>	Constant WIN_BASE of type <code>int</code>
<i>WIN_SIZE</i>	Constant WIN_SIZE of type <code>int</code>
<i>WIN_DISP_UNIT</i>	Constant WIN_DISP_UNIT of type <code>int</code>
<i>WIN_CREATE_FLAVOR</i>	Constant WIN_CREATE_FLAVOR of type <code>int</code>
<i>WIN_FLAVOR</i>	Constant WIN_FLAVOR of type <code>int</code>
<i>WIN_MODEL</i>	Constant WIN_MODEL of type <code>int</code>
<i>SUCCESS</i>	Constant SUCCESS of type <code>int</code>
<i>ERR_LASTCODE</i>	Constant ERR_LASTCODE of type <code>int</code>
<i>ERR_ABI</i>	Constant ERR_ABI of type <code>int</code>
<i>ERR_TYPE</i>	Constant ERR_TYPE of type <code>int</code>
<i>ERR_REQUEST</i>	Constant ERR_REQUEST of type <code>int</code>
<i>ERR_OP</i>	Constant ERR_OP of type <code>int</code>
<i>ERR_GROUP</i>	Constant ERR_GROUP of type <code>int</code>

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<i>ERR_INFO</i>	Constant <i>ERR_INFO</i> of type <i>int</i>
<i>ERR_ERRHANDLER</i>	Constant <i>ERR_ERRHANDLER</i> of type <i>int</i>
<i>ERR_SESSION</i>	Constant <i>ERR_SESSION</i> of type <i>int</i>
<i>ERR_COMM</i>	Constant <i>ERR_COMM</i> of type <i>int</i>
<i>ERR_WIN</i>	Constant <i>ERR_WIN</i> of type <i>int</i>
<i>ERR_FILE</i>	Constant <i>ERR_FILE</i> of type <i>int</i>
<i>ERR_BUFFER</i>	Constant <i>ERR_BUFFER</i> of type <i>int</i>
<i>ERR_COUNT</i>	Constant <i>ERR_COUNT</i> of type <i>int</i>
<i>ERR_TAG</i>	Constant <i>ERR_TAG</i> of type <i>int</i>
<i>ERR_RANK</i>	Constant <i>ERR_RANK</i> of type <i>int</i>
<i>ERR_ROOT</i>	Constant <i>ERR_ROOT</i> of type <i>int</i>
<i>ERR_TRUNCATE</i>	Constant <i>ERR_TRUNCATE</i> of type <i>int</i>
<i>ERR_IN_STATUS</i>	Constant <i>ERR_IN_STATUS</i> of type <i>int</i>
<i>ERR_PENDING</i>	Constant <i>ERR_PENDING</i> of type <i>int</i>
<i>ERR_TOPOLOGY</i>	Constant <i>ERR_TOPOLOGY</i> of type <i>int</i>
<i>ERR_DIMS</i>	Constant <i>ERR_DIMS</i> of type <i>int</i>
<i>ERR_ARG</i>	Constant <i>ERR_ARG</i> of type <i>int</i>
<i>ERR_OTHER</i>	Constant <i>ERR_OTHER</i> of type <i>int</i>
<i>ERR_UNKNOWN</i>	Constant <i>ERR_UNKNOWN</i> of type <i>int</i>
<i>ERR_INTERN</i>	Constant <i>ERR_INTERN</i> of type <i>int</i>
<i>ERR_KEYVAL</i>	Constant <i>ERR_KEYVAL</i> of type <i>int</i>
<i>ERR_NO_MEM</i>	Constant <i>ERR_NO_MEM</i> of type <i>int</i>
<i>ERR_INFO_KEY</i>	Constant <i>ERR_INFO_KEY</i> of type <i>int</i>
<i>ERR_INFO_VALUE</i>	Constant <i>ERR_INFO_VALUE</i> of type <i>int</i>
<i>ERR_INFO_NOKEY</i>	Constant <i>ERR_INFO_NOKEY</i> of type <i>int</i>
<i>ERR_SPAWN</i>	Constant <i>ERR_SPAWN</i> of type <i>int</i>
<i>ERR_PORT</i>	Constant <i>ERR_PORT</i> of type <i>int</i>
<i>ERR_SERVICE</i>	Constant <i>ERR_SERVICE</i> of type <i>int</i>
<i>ERR_NAME</i>	Constant <i>ERR_NAME</i> of type <i>int</i>
<i>ERR_PROC_ABORTED</i>	Constant <i>ERR_PROC_ABORTED</i> of type <i>int</i>
<i>ERR_BASE</i>	Constant <i>ERR_BASE</i> of type <i>int</i>
<i>ERR_SIZE</i>	Constant <i>ERR_SIZE</i> of type <i>int</i>
<i>ERR_DISP</i>	Constant <i>ERR_DISP</i> of type <i>int</i>
<i>ERR_ASSERT</i>	Constant <i>ERR_ASSERT</i> of type <i>int</i>
<i>ERR_LOCKTYPE</i>	Constant <i>ERR_LOCKTYPE</i> of type <i>int</i>
<i>ERR_RMA_CONFLICT</i>	Constant <i>ERR_RMA_CONFLICT</i> of type <i>int</i>
<i>ERR_RMA_SYNC</i>	Constant <i>ERR_RMA_SYNC</i> of type <i>int</i>
<i>ERR_RMA_RANGE</i>	Constant <i>ERR_RMA_RANGE</i> of type <i>int</i>
<i>ERR_RMA_ATTACH</i>	Constant <i>ERR_RMA_ATTACH</i> of type <i>int</i>
<i>ERR_RMA_SHARED</i>	Constant <i>ERR_RMA_SHARED</i> of type <i>int</i>
<i>ERR_RMA_FLAVOR</i>	Constant <i>ERR_RMA_FLAVOR</i> of type <i>int</i>
<i>ERR_BAD_FILE</i>	Constant <i>ERR_BAD_FILE</i> of type <i>int</i>
<i>ERR_NO_SUCH_FILE</i>	Constant <i>ERR_NO_SUCH_FILE</i> of type <i>int</i>
<i>ERR_FILE_EXISTS</i>	Constant <i>ERR_FILE_EXISTS</i> of type <i>int</i>
<i>ERR_FILE_IN_USE</i>	Constant <i>ERR_FILE_IN_USE</i> of type <i>int</i>
<i>ERR_AMODE</i>	Constant <i>ERR_AMODE</i> of type <i>int</i>
<i>ERR_ACCESS</i>	Constant <i>ERR_ACCESS</i> of type <i>int</i>
<i>ERR_READ_ONLY</i>	Constant <i>ERR_READ_ONLY</i> of type <i>int</i>
<i>ERR_NO_SPACE</i>	Constant <i>ERR_NO_SPACE</i> of type <i>int</i>
<i>ERR_QUOTA</i>	Constant <i>ERR_QUOTA</i> of type <i>int</i>
<i>ERR_NOT_SAME</i>	Constant <i>ERR_NOT_SAME</i> of type <i>int</i>
<i>ERR_IO</i>	Constant <i>ERR_IO</i> of type <i>int</i>

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<i>ERR_UNSUPPORTED_OPERATION</i>	Constant <i>ERR_UNSUPPORTED_OPERATION</i> of type <i>int</i>
<i>ERR_UNSUPPORTED_DATAREP</i>	Constant <i>ERR_UNSUPPORTED_DATAREP</i> of type <i>int</i>
<i>ERR_CONVERSION</i>	Constant <i>ERR_CONVERSION</i> of type <i>int</i>
<i>ERR_DUP_DATAREP</i>	Constant <i>ERR_DUP_DATAREP</i> of type <i>int</i>
<i>ERR_VALUE_TOO_LARGE</i>	Constant <i>ERR_VALUE_TOO_LARGE</i> of type <i>int</i>
<i>ERR_REVOKED</i>	Constant <i>ERR_REVOKED</i> of type <i>int</i>
<i>ERR_PROC_FAILED</i>	Constant <i>ERR_PROC_FAILED</i> of type <i>int</i>
<i>ERR_PROC_FAILED_PENDING</i>	Constant <i>ERR_PROC_FAILED_PENDING</i> of type <i>int</i>
<i>ORDER_C</i>	Constant <i>ORDER_C</i> of type <i>int</i>
<i>ORDER_FORTRAN</i>	Constant <i>ORDER_FORTRAN</i> of type <i>int</i>
<i>ORDER_F</i>	Constant <i>ORDER_F</i> of type <i>int</i>
<i>TYPECLASS_LOGICAL</i>	Constant <i>TYPECLASS_LOGICAL</i> of type <i>int</i>
<i>TYPECLASS_INTEGER</i>	Constant <i>TYPECLASS_INTEGER</i> of type <i>int</i>
<i>TYPECLASS_REAL</i>	Constant <i>TYPECLASS_REAL</i> of type <i>int</i>
<i>TYPECLASS_COMPLEX</i>	Constant <i>TYPECLASS_COMPLEX</i> of type <i>int</i>
<i>DISTRIBUTE_NONE</i>	Constant <i>DISTRIBUTE_NONE</i> of type <i>int</i>
<i>DISTRIBUTE_BLOCK</i>	Constant <i>DISTRIBUTE_BLOCK</i> of type <i>int</i>
<i>DISTRIBUTE_CYCLIC</i>	Constant <i>DISTRIBUTE_CYCLIC</i> of type <i>int</i>
<i>DISTRIBUTE_DFLT_DARG</i>	Constant <i>DISTRIBUTE_DFLT_DARG</i> of type <i>int</i>
<i>COMBINER_NAMED</i>	Constant <i>COMBINER_NAMED</i> of type <i>int</i>
<i>COMBINER_DUP</i>	Constant <i>COMBINER_DUP</i> of type <i>int</i>
<i>COMBINER_CONTIGUOUS</i>	Constant <i>COMBINER_CONTIGUOUS</i> of type <i>int</i>
<i>COMBINER_VECTOR</i>	Constant <i>COMBINER_VECTOR</i> of type <i>int</i>
<i>COMBINER_HVECTOR</i>	Constant <i>COMBINER_HVECTOR</i> of type <i>int</i>
<i>COMBINER_INDEXED</i>	Constant <i>COMBINER_INDEXED</i> of type <i>int</i>
<i>COMBINER_HINDEXED</i>	Constant <i>COMBINER_HINDEXED</i> of type <i>int</i>
<i>COMBINER_INDEXED_BLOCK</i>	Constant <i>COMBINER_INDEXED_BLOCK</i> of type <i>int</i>
<i>COMBINER_HINDEXED_BLOCK</i>	Constant <i>COMBINER_HINDEXED_BLOCK</i> of type <i>int</i>
<i>COMBINER_STRUCT</i>	Constant <i>COMBINER_STRUCT</i> of type <i>int</i>
<i>COMBINER_SUBARRAY</i>	Constant <i>COMBINER_SUBARRAY</i> of type <i>int</i>
<i>COMBINER_DARRAY</i>	Constant <i>COMBINER_DARRAY</i> of type <i>int</i>
<i>COMBINER_RESIZED</i>	Constant <i>COMBINER_RESIZED</i> of type <i>int</i>
<i>COMBINER_VALUE_INDEX</i>	Constant <i>COMBINER_VALUE_INDEX</i> of type <i>int</i>
<i>COMBINER_F90_INTEGER</i>	Constant <i>COMBINER_F90_INTEGER</i> of type <i>int</i>
<i>COMBINER_F90_REAL</i>	Constant <i>COMBINER_F90_REAL</i> of type <i>int</i>
<i>COMBINER_F90_COMPLEX</i>	Constant <i>COMBINER_F90_COMPLEX</i> of type <i>int</i>
<i>F_SOURCE</i>	Constant <i>F_SOURCE</i> of type <i>int</i>
<i>F_TAG</i>	Constant <i>F_TAG</i> of type <i>int</i>
<i>F_ERROR</i>	Constant <i>F_ERROR</i> of type <i>int</i>
<i>F_STATUS_SIZE</i>	Constant <i>F_STATUS_SIZE</i> of type <i>int</i>
<i>IDENT</i>	Constant <i>IDENT</i> of type <i>int</i>
<i>CONGRUENT</i>	Constant <i>CONGRUENT</i> of type <i>int</i>
<i>SIMILAR</i>	Constant <i>SIMILAR</i> of type <i>int</i>
<i>UNEQUAL</i>	Constant <i>UNEQUAL</i> of type <i>int</i>
<i>CART</i>	Constant <i>CART</i> of type <i>int</i>
<i>GRAPH</i>	Constant <i>GRAPH</i> of type <i>int</i>
<i>DIST_GRAPH</i>	Constant <i>DIST_GRAPH</i> of type <i>int</i>
<i>UNWEIGHTED</i>	Constant <i>UNWEIGHTED</i> of type <i>int</i>
<i>WEIGHTS_EMPTY</i>	Constant <i>WEIGHTS_EMPTY</i> of type <i>int</i>
<i>COMM_TYPE_SHARED</i>	Constant <i>COMM_TYPE_SHARED</i> of type <i>int</i>
<i>COMM_TYPE_HW_GUIDED</i>	Constant <i>COMM_TYPE_HW_GUIDED</i> of type <i>int</i>
<i>COMM_TYPE_HW_UNGUIDED</i>	Constant <i>COMM_TYPE_HW_UNGUIDED</i> of type <i>int</i>

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<i>COMM_TYPE_RESOURCE_GUIDED</i>	Constant <i>COMM_TYPE_RESOURCE_GUIDED</i> of type <i>int</i>
<i>BSEND_OVERHEAD</i>	Constant <i>BSEND_OVERHEAD</i> of type <i>int</i>
<i>WIN_FLAVOR_CREATE</i>	Constant <i>WIN_FLAVOR_CREATE</i> of type <i>int</i>
<i>WIN_FLAVOR_ALLOCATE</i>	Constant <i>WIN_FLAVOR_ALLOCATE</i> of type <i>int</i>
<i>WIN_FLAVOR_DYNAMIC</i>	Constant <i>WIN_FLAVOR_DYNAMIC</i> of type <i>int</i>
<i>WIN_FLAVOR_SHARED</i>	Constant <i>WIN_FLAVOR_SHARED</i> of type <i>int</i>
<i>WIN_SEPARATE</i>	Constant <i>WIN_SEPARATE</i> of type <i>int</i>
<i>WIN_UNIFIED</i>	Constant <i>WIN_UNIFIED</i> of type <i>int</i>
<i>MODE_NOCHECK</i>	Constant <i>MODE_NOCHECK</i> of type <i>int</i>
<i>MODE_NOSTORE</i>	Constant <i>MODE_NOSTORE</i> of type <i>int</i>
<i>MODE_NOPUT</i>	Constant <i>MODE_NOPUT</i> of type <i>int</i>
<i>MODE_NOPRECEDE</i>	Constant <i>MODE_NOPRECEDE</i> of type <i>int</i>
<i>MODE_NOSUCCEED</i>	Constant <i>MODE_NOSUCCEED</i> of type <i>int</i>
<i>LOCK_EXCLUSIVE</i>	Constant <i>LOCK_EXCLUSIVE</i> of type <i>int</i>
<i>LOCK_SHARED</i>	Constant <i>LOCK_SHARED</i> of type <i>int</i>
<i>MODE_RDONLY</i>	Constant <i>MODE_RDONLY</i> of type <i>int</i>
<i>MODE_WRONLY</i>	Constant <i>MODE_WRONLY</i> of type <i>int</i>
<i>MODE_RDWR</i>	Constant <i>MODE_RDWR</i> of type <i>int</i>
<i>MODE_CREATE</i>	Constant <i>MODE_CREATE</i> of type <i>int</i>
<i>MODE_EXCL</i>	Constant <i>MODE_EXCL</i> of type <i>int</i>
<i>MODE_DELETE_ON_CLOSE</i>	Constant <i>MODE_DELETE_ON_CLOSE</i> of type <i>int</i>
<i>MODE_UNIQUE_OPEN</i>	Constant <i>MODE_UNIQUE_OPEN</i> of type <i>int</i>
<i>MODE_SEQUENTIAL</i>	Constant <i>MODE_SEQUENTIAL</i> of type <i>int</i>
<i>MODE_APPEND</i>	Constant <i>MODE_APPEND</i> of type <i>int</i>
<i>SEEK_SET</i>	Constant <i>SEEK_SET</i> of type <i>int</i>
<i>SEEK_CUR</i>	Constant <i>SEEK_CUR</i> of type <i>int</i>
<i>SEEK_END</i>	Constant <i>SEEK_END</i> of type <i>int</i>
<i>DISPLACEMENT_CURRENT</i>	Constant <i>DISPLACEMENT_CURRENT</i> of type <i>int</i>
<i>DISP_CUR</i>	Constant <i>DISP_CUR</i> of type <i>int</i>
<i>THREAD_SINGLE</i>	Constant <i>THREAD_SINGLE</i> of type <i>int</i>
<i>THREAD_FUNNELED</i>	Constant <i>THREAD_FUNNELED</i> of type <i>int</i>
<i>THREAD_SERIALIZED</i>	Constant <i>THREAD_SERIALIZED</i> of type <i>int</i>
<i>THREAD_MULTIPLE</i>	Constant <i>THREAD_MULTIPLE</i> of type <i>int</i>
<i>VERSION</i>	Constant <i>VERSION</i> of type <i>int</i>
<i>SUBVERSION</i>	Constant <i>SUBVERSION</i> of type <i>int</i>
<i>MAX_PROCESSOR_NAME</i>	Constant <i>MAX_PROCESSOR_NAME</i> of type <i>int</i>
<i>MAX_ERROR_STRING</i>	Constant <i>MAX_ERROR_STRING</i> of type <i>int</i>
<i>MAX_PORT_NAME</i>	Constant <i>MAX_PORT_NAME</i> of type <i>int</i>
<i>MAX_INFO_KEY</i>	Constant <i>MAX_INFO_KEY</i> of type <i>int</i>
<i>MAX_INFO_VAL</i>	Constant <i>MAX_INFO_VAL</i> of type <i>int</i>
<i>MAX_OBJECT_NAME</i>	Constant <i>MAX_OBJECT_NAME</i> of type <i>int</i>
<i>MAX_DATAREP_STRING</i>	Constant <i>MAX_DATAREP_STRING</i> of type <i>int</i>
<i>MAX_LIBRARY_VERSION_STRING</i>	Constant <i>MAX_LIBRARY_VERSION_STRING</i> of type <i>int</i>
<i>MAX_PSET_NAME_LEN</i>	Constant <i>MAX_PSET_NAME_LEN</i> of type <i>int</i>
<i>MAX_STRINGTAG_LEN</i>	Constant <i>MAX_STRINGTAG_LEN</i> of type <i>int</i>
<i>DATATYPE_NULL</i>	Object <i>DATATYPE_NULL</i> of type <i>Datatype</i>
<i>PACKED</i>	Object <i>PACKED</i> of type <i>Datatype</i>
<i>BYTE</i>	Object <i>BYTE</i> of type <i>Datatype</i>
<i>AINT</i>	Object <i>AINT</i> of type <i>Datatype</i>
<i>OFFSET</i>	Object <i>OFFSET</i> of type <i>Datatype</i>
<i>COUNT</i>	Object <i>COUNT</i> of type <i>Datatype</i>
<i>CHAR</i>	Object <i>CHAR</i> of type <i>Datatype</i>

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Table 64 – continued from previous page

WCHAR	Object WCHAR of type <i>Datatype</i>
SIGNED_CHAR	Object SIGNED_CHAR of type <i>Datatype</i>
SHORT	Object SHORT of type <i>Datatype</i>
INT	Object INT of type <i>Datatype</i>
LONG	Object LONG of type <i>Datatype</i>
LONG_LONG	Object LONG_LONG of type <i>Datatype</i>
UNSIGNED_CHAR	Object UNSIGNED_CHAR of type <i>Datatype</i>
UNSIGNED_SHORT	Object UNSIGNED_SHORT of type <i>Datatype</i>
UNSIGNED	Object UNSIGNED of type <i>Datatype</i>
UNSIGNED_LONG	Object UNSIGNED_LONG of type <i>Datatype</i>
UNSIGNED_LONG_LONG	Object UNSIGNED_LONG_LONG of type <i>Datatype</i>
FLOAT	Object FLOAT of type <i>Datatype</i>
DOUBLE	Object DOUBLE of type <i>Datatype</i>
LONG_DOUBLE	Object LONG_DOUBLE of type <i>Datatype</i>
C_BOOL	Object C_BOOL of type <i>Datatype</i>
INT8_T	Object INT8_T of type <i>Datatype</i>
INT16_T	Object INT16_T of type <i>Datatype</i>
INT32_T	Object INT32_T of type <i>Datatype</i>
INT64_T	Object INT64_T of type <i>Datatype</i>
UINT8_T	Object UINT8_T of type <i>Datatype</i>
UINT16_T	Object UINT16_T of type <i>Datatype</i>
UINT32_T	Object UINT32_T of type <i>Datatype</i>
UINT64_T	Object UINT64_T of type <i>Datatype</i>
FLOAT16_T	Object FLOAT16_T of type <i>Datatype</i>
FLOAT32_T	Object FLOAT32_T of type <i>Datatype</i>
FLOAT64_T	Object FLOAT64_T of type <i>Datatype</i>
BFLOAT16_T	Object BFLOAT16_T of type <i>Datatype</i>
C_COMPLEX	Object C_COMPLEX of type <i>Datatype</i>
C_FLOAT_COMPLEX	Object C_FLOAT_COMPLEX of type <i>Datatype</i>
C_DOUBLE_COMPLEX	Object C_DOUBLE_COMPLEX of type <i>Datatype</i>
C_LONG_DOUBLE_COMPLEX	Object C_LONG_DOUBLE_COMPLEX of type <i>Datatype</i>
CXX_BOOL	Object CXX_BOOL of type <i>Datatype</i>
CXX_FLOAT_COMPLEX	Object CXX_FLOAT_COMPLEX of type <i>Datatype</i>
CXX_DOUBLE_COMPLEX	Object CXX_DOUBLE_COMPLEX of type <i>Datatype</i>
CXX_LONG_DOUBLE_COMPLEX	Object CXX_LONG_DOUBLE_COMPLEX of type <i>Datatype</i>
SHORT_INT	Object SHORT_INT of type <i>Datatype</i>
INT_INT	Object INT_INT of type <i>Datatype</i>
TWOINT	Object TWOINT of type <i>Datatype</i>
LONG_INT	Object LONG_INT of type <i>Datatype</i>
FLOAT_INT	Object FLOAT_INT of type <i>Datatype</i>
DOUBLE_INT	Object DOUBLE_INT of type <i>Datatype</i>
LONG_DOUBLE_INT	Object LONG_DOUBLE_INT of type <i>Datatype</i>
CHARACTER	Object CHARACTER of type <i>Datatype</i>
LOGICAL	Object LOGICAL of type <i>Datatype</i>
INTEGER	Object INTEGER of type <i>Datatype</i>
REAL	Object REAL of type <i>Datatype</i>
DOUBLE_PRECISION	Object DOUBLE_PRECISION of type <i>Datatype</i>
COMPLEX	Object COMPLEX of type <i>Datatype</i>
DOUBLE_COMPLEX	Object DOUBLE_COMPLEX of type <i>Datatype</i>
LOGICAL1	Object LOGICAL1 of type <i>Datatype</i>
LOGICAL2	Object LOGICAL2 of type <i>Datatype</i>
LOGICAL4	Object LOGICAL4 of type <i>Datatype</i>

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Table 64 – continued from previous page

LOGICAL8	Object LOGICAL8 of type <i>Datatype</i>
LOGICAL16	Object LOGICAL16 of type <i>Datatype</i>
INTEGER1	Object INTEGER1 of type <i>Datatype</i>
INTEGER2	Object INTEGER2 of type <i>Datatype</i>
INTEGER4	Object INTEGER4 of type <i>Datatype</i>
INTEGER8	Object INTEGER8 of type <i>Datatype</i>
INTEGER16	Object INTEGER16 of type <i>Datatype</i>
REAL2	Object REAL2 of type <i>Datatype</i>
REAL4	Object REAL4 of type <i>Datatype</i>
REAL8	Object REAL8 of type <i>Datatype</i>
REAL16	Object REAL16 of type <i>Datatype</i>
COMPLEX4	Object COMPLEX4 of type <i>Datatype</i>
COMPLEX8	Object COMPLEX8 of type <i>Datatype</i>
COMPLEX16	Object COMPLEX16 of type <i>Datatype</i>
COMPLEX32	Object COMPLEX32 of type <i>Datatype</i>
UNSIGNED_INT	Object UNSIGNED_INT of type <i>Datatype</i>
SIGNED_SHORT	Object SIGNED_SHORT of type <i>Datatype</i>
SIGNED_INT	Object SIGNED_INT of type <i>Datatype</i>
SIGNED_LONG	Object SIGNED_LONG of type <i>Datatype</i>
SIGNED_LONG_LONG	Object SIGNED_LONG_LONG of type <i>Datatype</i>
BOOL	Object BOOL of type <i>Datatype</i>
SINT8_T	Object SINT8_T of type <i>Datatype</i>
SINT16_T	Object SINT16_T of type <i>Datatype</i>
SINT32_T	Object SINT32_T of type <i>Datatype</i>
SINT64_T	Object SINT64_T of type <i>Datatype</i>
F_BOOL	Object F_BOOL of type <i>Datatype</i>
F_INT	Object F_INT of type <i>Datatype</i>
F_FLOAT	Object F_FLOAT of type <i>Datatype</i>
F_DOUBLE	Object F_DOUBLE of type <i>Datatype</i>
F_COMPLEX	Object F_COMPLEX of type <i>Datatype</i>
F_FLOAT_COMPLEX	Object F_FLOAT_COMPLEX of type <i>Datatype</i>
F_DOUBLE_COMPLEX	Object F_DOUBLE_COMPLEX of type <i>Datatype</i>
REQUEST_NULL	Object REQUEST_NULL of type <i>Request</i>
MESSAGE_NULL	Object MESSAGE_NULL of type <i>Message</i>
MESSAGE_NO_PROC	Object MESSAGE_NO_PROC of type <i>Message</i>
OP_NULL	Object OP_NULL of type <i>Op</i>
MAX	Object MAX of type <i>Op</i>
MIN	Object MIN of type <i>Op</i>
SUM	Object SUM of type <i>Op</i>
PROD	Object PROD of type <i>Op</i>
LAND	Object LAND of type <i>Op</i>
BAND	Object BAND of type <i>Op</i>
LOR	Object LOR of type <i>Op</i>
BOR	Object BOR of type <i>Op</i>
LXOR	Object LXOR of type <i>Op</i>
BXOR	Object BXOR of type <i>Op</i>
MAXLOC	Object MAXLOC of type <i>Op</i>
MINLOC	Object MINLOC of type <i>Op</i>
REPLACE	Object REPLACE of type <i>Op</i>
NO_OP	Object NO_OP of type <i>Op</i>
GROUP_NULL	Object GROUP_NULL of type <i>Group</i>
GROUP_EMPTY	Object GROUP_EMPTY of type <i>Group</i>

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Table 64 – continued from previous page

<i>INFO_NULL</i>	Object <i>INFO_NULL</i> of type <i>Info</i>
<i>INFO_ENV</i>	Object <i>INFO_ENV</i> of type <i>Info</i>
<i>ERRHANDLER_NULL</i>	Object <i>ERRHANDLER_NULL</i> of type <i>Errhandler</i>
<i>ERRORS_RETURN</i>	Object <i>ERRORS_RETURN</i> of type <i>Errhandler</i>
<i>ERRORS_ABORT</i>	Object <i>ERRORS_ABORT</i> of type <i>Errhandler</i>
<i>ERRORS_ARE_FATAL</i>	Object <i>ERRORS_ARE_FATAL</i> of type <i>Errhandler</i>
<i>SESSION_NULL</i>	Object <i>SESSION_NULL</i> of type <i>Session</i>
<i>COMM_NULL</i>	Object <i>COMM_NULL</i> of type <i>Comm</i>
<i>COMM_SELF</i>	Object <i>COMM_SELF</i> of type <i>Intracomm</i>
<i>COMM_WORLD</i>	Object <i>COMM_WORLD</i> of type <i>Intracomm</i>
<i>WIN_NULL</i>	Object <i>WIN_NULL</i> of type <i>Win</i>
<i>FILE_NULL</i>	Object <i>FILE_NULL</i> of type <i>File</i>
<i>BOTTOM</i>	Object <i>BOTTOM</i> of type <i>BottomType</i>
<i>IN_PLACE</i>	Object <i>IN_PLACE</i> of type <i>InPlaceType</i>
<i>BUFFER_AUTOMATIC</i>	Object <i>BUFFER_AUTOMATIC</i> of type <i>BufferAutomaticType</i>
<i>pickle</i>	Object <i>pickle</i> of type <i>Pickle</i>

mpi4py.MPI.UNDEFINED

`mpi4py.MPI.UNDEFINED: int = UNDEFINED`

Constant *UNDEFINED* of type *int*

mpi4py.MPI.ANY_SOURCE

`mpi4py.MPI.ANY_SOURCE: int = ANY_SOURCE`

Constant *ANY_SOURCE* of type *int*

mpi4py.MPI.ANY_TAG

`mpi4py.MPI.ANY_TAG: int = ANY_TAG`

Constant *ANY_TAG* of type *int*

mpi4py.MPI.PROC_NULL

`mpi4py.MPI.PROC_NULL: int = PROC_NULL`

Constant *PROC_NULL* of type *int*

mpi4py.MPI.ROOT

`mpi4py.MPI.ROOT: int = ROOT`

Constant *ROOT* of type *int*

mpi4py.MPI.KEYVAL_INVALID

`mpi4py.MPI.KEYVAL_INVALID: int = KEYVAL_INVALID`

Constant *KEYVAL_INVALID* of type *int*

mpi4py.MPI.TAG_UB

`mpi4py.MPI.TAG_UB: int = TAG_UB`

Constant *TAG_UB* of type *int*

mpi4py.MPI.IO

`mpi4py.MPI.IO: int = IO`

Constant IO of type `int`

mpi4py.MPI.WTIME_IS_GLOBAL

`mpi4py.MPI.WTIME_IS_GLOBAL: int = WTIME_IS_GLOBAL`

Constant WTIME_IS_GLOBAL of type `int`

mpi4py.MPI.UNIVERSE_SIZE

`mpi4py.MPI.UNIVERSE_SIZE: int = UNIVERSE_SIZE`

Constant UNIVERSE_SIZE of type `int`

mpi4py.MPI.APPNUM

`mpi4py.MPI.APPNUM: int = APPNUM`

Constant APPNUM of type `int`

mpi4py.MPI.LASTUSEDPCODE

`mpi4py.MPI.LASTUSEDPCODE: int = LASTUSEDPCODE`

Constant LASTUSEDPCODE of type `int`

mpi4py.MPI.WIN_BASE

`mpi4py.MPI.WIN_BASE: int = WIN_BASE`

Constant WIN_BASE of type `int`

mpi4py.MPI.WIN_SIZE

`mpi4py.MPI.WIN_SIZE: int = WIN_SIZE`

Constant WIN_SIZE of type `int`

mpi4py.MPI.WIN_DISP_UNIT

`mpi4py.MPI.WIN_DISP_UNIT: int = WIN_DISP_UNIT`

Constant WIN_DISP_UNIT of type `int`

mpi4py.MPI.WIN_CREATE_FLAVOR

`mpi4py.MPI.WIN_CREATE_FLAVOR: int = WIN_CREATE_FLAVOR`

Constant WIN_CREATE_FLAVOR of type `int`

mpi4py.MPI.WIN_FLAVOR

`mpi4py.MPI.WIN_FLAVOR: int = WIN_FLAVOR`

Constant WIN_FLAVOR of type `int`

mpi4py.MPI.WIN_MODEL

`mpi4py.MPI.WIN_MODEL: int = WIN_MODEL`

Constant WIN_MODEL of type `int`

mpi4py.MPI.SUCCESS

`mpi4py.MPI.SUCCESS: int = SUCCESS`

Constant SUCCESS of type `int`

mpi4py.MPI.ERR_LASTCODE

`mpi4py.MPI.ERR_LASTCODE: int = ERR_LASTCODE`

Constant ERR_LASTCODE of type `int`

mpi4py.MPI.ERR_ABI

`mpi4py.MPI.ERR_ABI: int = ERR_ABI`

Constant ERR_ABI of type `int`

mpi4py.MPI.ERR_TYPE

`mpi4py.MPI.ERR_TYPE: int = ERR_TYPE`

Constant ERR_TYPE of type `int`

mpi4py.MPI.ERR_REQUEST

`mpi4py.MPI.ERR_REQUEST: int = ERR_REQUEST`

Constant ERR_REQUEST of type `int`

mpi4py.MPI.ERR_OP

`mpi4py.MPI.ERR_OP: int = ERR_OP`

Constant ERR_OP of type `int`

mpi4py.MPI.ERR_GROUP

`mpi4py.MPI.ERR_GROUP: int = ERR_GROUP`

Constant ERR_GROUP of type `int`

mpi4py.MPI.ERR_INFO

`mpi4py.MPI.ERR_INFO: int = ERR_INFO`

Constant ERR_INFO of type `int`

mpi4py.MPI.ERR_ERRHANDLER

`mpi4py.MPI.ERR_ERRHANDLER: int = ERR_ERRHANDLER`

Constant ERR_ERRHANDLER of type `int`

mpi4py.MPI.ERR_SESSION

`mpi4py.MPI.ERR_SESSION: int = ERR_SESSION`

Constant ERR_SESSION of type `int`

mpi4py.MPI.ERR_COMM

`mpi4py.MPI.ERR_COMM: int = ERR_COMM`

Constant ERR_COMM of type `int`

mpi4py.MPI.ERR_WIN

`mpi4py.MPI.ERR_WIN: int = ERR_WIN`

Constant `ERR_WIN` of type `int`

mpi4py.MPI.ERR_FILE

`mpi4py.MPI.ERR_FILE: int = ERR_FILE`

Constant `ERR_FILE` of type `int`

mpi4py.MPI.ERR_BUFFER

`mpi4py.MPI.ERR_BUFFER: int = ERR_BUFFER`

Constant `ERR_BUFFER` of type `int`

mpi4py.MPI.ERR_COUNT

`mpi4py.MPI.ERR_COUNT: int = ERR_COUNT`

Constant `ERR_COUNT` of type `int`

mpi4py.MPI.ERR_TAG

`mpi4py.MPI.ERR_TAG: int = ERR_TAG`

Constant `ERR_TAG` of type `int`

mpi4py.MPI.ERR_RANK

`mpi4py.MPI.ERR_RANK: int = ERR_RANK`

Constant `ERR_RANK` of type `int`

mpi4py.MPI.ERR_ROOT

`mpi4py.MPI.ERR_ROOT: int = ERR_ROOT`

Constant `ERR_ROOT` of type `int`

mpi4py.MPI.ERR_TRUNCATE

`mpi4py.MPI.ERR_TRUNCATE: int = ERR_TRUNCATE`

Constant `ERR_TRUNCATE` of type `int`

mpi4py.MPI.ERR_IN_STATUS

`mpi4py.MPI.ERR_IN_STATUS: int = ERR_IN_STATUS`

Constant `ERR_IN_STATUS` of type `int`

mpi4py.MPI.ERR_PENDING

`mpi4py.MPI.ERR_PENDING: int = ERR_PENDING`

Constant `ERR_PENDING` of type `int`

mpi4py.MPI.ERR_TOPOLOGY

`mpi4py.MPI.ERR_TOPOLOGY: int = ERR_TOPOLOGY`

Constant `ERR_TOPOLOGY` of type `int`

mpi4py.MPI.ERR_DIMS

`mpi4py.MPI.ERR_DIMS: int = ERR_DIMS`

Constant `ERR_DIMS` of type `int`

mpi4py.MPI.ERR_ARG

`mpi4py.MPI.ERR_ARG: int = ERR_ARG`

Constant `ERR_ARG` of type `int`

mpi4py.MPI.ERR_OTHER

`mpi4py.MPI.ERR_OTHER: int = ERR_OTHER`

Constant `ERR_OTHER` of type `int`

mpi4py.MPI.ERR_UNKNOWN

`mpi4py.MPI.ERR_UNKNOWN: int = ERR_UNKNOWN`

Constant `ERR_UNKNOWN` of type `int`

mpi4py.MPI.ERR_INTERN

`mpi4py.MPI.ERR_INTERN: int = ERR_INTERN`

Constant `ERR_INTERN` of type `int`

mpi4py.MPI.ERR_KEYVAL

`mpi4py.MPI.ERR_KEYVAL: int = ERR_KEYVAL`

Constant `ERR_KEYVAL` of type `int`

mpi4py.MPI.ERR_NO_MEM

`mpi4py.MPI.ERR_NO_MEM: int = ERR_NO_MEM`

Constant `ERR_NO_MEM` of type `int`

mpi4py.MPI.ERR_INFO_KEY

`mpi4py.MPI.ERR_INFO_KEY: int = ERR_INFO_KEY`

Constant `ERR_INFO_KEY` of type `int`

mpi4py.MPI.ERR_INFO_VALUE

`mpi4py.MPI.ERR_INFO_VALUE: int = ERR_INFO_VALUE`

Constant `ERR_INFO_VALUE` of type `int`

mpi4py.MPI.ERR_INFO_NOKEY

`mpi4py.MPI.ERR_INFO_NOKEY: int = ERR_INFO_NOKEY`

Constant `ERR_INFO_NOKEY` of type `int`

mpi4py.MPI.ERR_SPAWN

`mpi4py.MPI.ERR_SPAWN: int = ERR_SPAWN`

Constant `ERR_SPAWN` of type `int`

mpi4py.MPI.ERR_PORT

`mpi4py.MPI.ERR_PORT: int = ERR_PORT`

Constant ERR_PORT of type `int`

mpi4py.MPI.ERR_SERVICE

`mpi4py.MPI.ERR_SERVICE: int = ERR_SERVICE`

Constant ERR_SERVICE of type `int`

mpi4py.MPI.ERR_NAME

`mpi4py.MPI.ERR_NAME: int = ERR_NAME`

Constant ERR_NAME of type `int`

mpi4py.MPI.ERR_PROC_ABORTED

`mpi4py.MPI.ERR_PROC_ABORTED: int = ERR_PROC_ABORTED`

Constant ERR_PROC_ABORTED of type `int`

mpi4py.MPI.ERR_BASE

`mpi4py.MPI.ERR_BASE: int = ERR_BASE`

Constant ERR_BASE of type `int`

mpi4py.MPI.ERR_SIZE

`mpi4py.MPI.ERR_SIZE: int = ERR_SIZE`

Constant ERR_SIZE of type `int`

mpi4py.MPI.ERR_DISP

`mpi4py.MPI.ERR_DISP: int = ERR_DISP`

Constant ERR_DISP of type `int`

mpi4py.MPI.ERR_ASSERT

`mpi4py.MPI.ERR_ASSERT: int = ERR_ASSERT`

Constant ERR_ASSERT of type `int`

mpi4py.MPI.ERR_LOCKTYPE

`mpi4py.MPI.ERR_LOCKTYPE: int = ERR_LOCKTYPE`

Constant ERR_LOCKTYPE of type `int`

mpi4py.MPI.ERR_RMA_CONFLICT

`mpi4py.MPI.ERR_RMA_CONFLICT: int = ERR_RMA_CONFLICT`

Constant ERR_RMA_CONFLICT of type `int`

mpi4py.MPI.ERR_RMA_SYNC

`mpi4py.MPI.ERR_RMA_SYNC: int = ERR_RMA_SYNC`

Constant ERR_RMA_SYNC of type `int`

mpi4py.MPI.ERR_RMA_RANGE

`mpi4py.MPI.ERR_RMA_RANGE: int = ERR_RMA_RANGE`

Constant ERR_RMA_RANGE of type `int`

mpi4py.MPI.ERR_RMA_ATTACH

`mpi4py.MPI.ERR_RMA_ATTACH: int = ERR_RMA_ATTACH`

Constant ERR_RMA_ATTACH of type `int`

mpi4py.MPI.ERR_RMA_SHARED

`mpi4py.MPI.ERR_RMA_SHARED: int = ERR_RMA_SHARED`

Constant ERR_RMA_SHARED of type `int`

mpi4py.MPI.ERR_RMA_FLAVOR

`mpi4py.MPI.ERR_RMA_FLAVOR: int = ERR_RMA_FLAVOR`

Constant ERR_RMA_FLAVOR of type `int`

mpi4py.MPI.ERR_BAD_FILE

`mpi4py.MPI.ERR_BAD_FILE: int = ERR_BAD_FILE`

Constant ERR_BAD_FILE of type `int`

mpi4py.MPI.ERR_NO_SUCH_FILE

`mpi4py.MPI.ERR_NO_SUCH_FILE: int = ERR_NO_SUCH_FILE`

Constant ERR_NO_SUCH_FILE of type `int`

mpi4py.MPI.ERR_FILE_EXISTS

`mpi4py.MPI.ERR_FILE_EXISTS: int = ERR_FILE_EXISTS`

Constant ERR_FILE_EXISTS of type `int`

mpi4py.MPI.ERR_FILE_IN_USE

`mpi4py.MPI.ERR_FILE_IN_USE: int = ERR_FILE_IN_USE`

Constant ERR_FILE_IN_USE of type `int`

mpi4py.MPI.ERR_AMODE

`mpi4py.MPI.ERR_AMODE: int = ERR_AMODE`

Constant ERR_AMODE of type `int`

mpi4py.MPI.ERR_ACCESS

`mpi4py.MPI.ERR_ACCESS: int = ERR_ACCESS`

Constant ERR_ACCESS of type `int`

mpi4py.MPI.ERR_READ_ONLY

`mpi4py.MPI.ERR_READ_ONLY: int = ERR_READ_ONLY`

Constant ERR_READ_ONLY of type `int`

mpi4py.MPI.ERR_NO_SPACE

`mpi4py.MPI.ERR_NO_SPACE: int = ERR_NO_SPACE`

Constant `ERR_NO_SPACE` of type `int`

mpi4py.MPI.ERR_QUOTA

`mpi4py.MPI.ERR_QUOTA: int = ERR_QUOTA`

Constant `ERR_QUOTA` of type `int`

mpi4py.MPI.ERR_NOT_SAME

`mpi4py.MPI.ERR_NOT_SAME: int = ERR_NOT_SAME`

Constant `ERR_NOT_SAME` of type `int`

mpi4py.MPI.ERR_IO

`mpi4py.MPI.ERR_IO: int = ERR_IO`

Constant `ERR_IO` of type `int`

mpi4py.MPI.ERR_UNSUPPORTED_OPERATION

`mpi4py.MPI.ERR_UNSUPPORTED_OPERATION: int = ERR_UNSUPPORTED_OPERATION`

Constant `ERR_UNSUPPORTED_OPERATION` of type `int`

mpi4py.MPI.ERR_UNSUPPORTED_DATAREP

`mpi4py.MPI.ERR_UNSUPPORTED_DATAREP: int = ERR_UNSUPPORTED_DATAREP`

Constant `ERR_UNSUPPORTED_DATAREP` of type `int`

mpi4py.MPI.ERR_CONVERSION

`mpi4py.MPI.ERR_CONVERSION: int = ERR_CONVERSION`

Constant `ERR_CONVERSION` of type `int`

mpi4py.MPI.ERR_DUP_DATAREP

`mpi4py.MPI.ERR_DUP_DATAREP: int = ERR_DUP_DATAREP`

Constant `ERR_DUP_DATAREP` of type `int`

mpi4py.MPI.ERR_VALUE_TOO_LARGE

`mpi4py.MPI.ERR_VALUE_TOO_LARGE: int = ERR_VALUE_TOO_LARGE`

Constant `ERR_VALUE_TOO_LARGE` of type `int`

mpi4py.MPI.ERR_REVOKED

`mpi4py.MPI.ERR_REVOKED: int = ERR_REVOKED`

Constant `ERR_REVOKED` of type `int`

mpi4py.MPI.ERR_PROC_FAILED

`mpi4py.MPI.ERR_PROC_FAILED: int = ERR_PROC_FAILED`

Constant `ERR_PROC_FAILED` of type `int`

mpi4py.MPI.ERR_PROC_FAILED_PENDING

`mpi4py.MPI.ERR_PROC_FAILED_PENDING: int = ERR_PROC_FAILED_PENDING`

Constant `ERR_PROC_FAILED_PENDING` of type `int`

mpi4py.MPI.ORDER_C

`mpi4py.MPI.ORDER_C: int = ORDER_C`

Constant `ORDER_C` of type `int`

mpi4py.MPI.ORDER_FORTRAN

`mpi4py.MPI.ORDER_FORTRAN: int = ORDER_FORTRAN`

Constant `ORDER_FORTRAN` of type `int`

mpi4py.MPI.ORDER_F

`mpi4py.MPI.ORDER_F: int = ORDER_F`

Constant `ORDER_F` of type `int`

mpi4py.MPI.TYPECLASS_LOGICAL

`mpi4py.MPI.TYPECLASS_LOGICAL: int = TYPECLASS_LOGICAL`

Constant `TYPECLASS_LOGICAL` of type `int`

mpi4py.MPI.TYPECLASS_INTEGER

`mpi4py.MPI.TYPECLASS_INTEGER: int = TYPECLASS_INTEGER`

Constant `TYPECLASS_INTEGER` of type `int`

mpi4py.MPI.TYPECLASS_REAL

`mpi4py.MPI.TYPECLASS_REAL: int = TYPECLASS_REAL`

Constant `TYPECLASS_REAL` of type `int`

mpi4py.MPI.TYPECLASS_COMPLEX

`mpi4py.MPI.TYPECLASS_COMPLEX: int = TYPECLASS_COMPLEX`

Constant `TYPECLASS_COMPLEX` of type `int`

mpi4py.MPI.DISTRIBUTE_NONE

`mpi4py.MPI.DISTRIBUTE_NONE: int = DISTRIBUTE_NONE`

Constant `DISTRIBUTE_NONE` of type `int`

mpi4py.MPI.DISTRIBUTE_BLOCK

`mpi4py.MPI.DISTRIBUTE_BLOCK: int = DISTRIBUTE_BLOCK`

Constant `DISTRIBUTE_BLOCK` of type `int`

mpi4py.MPI.DISTRIBUTE_CYCLIC

`mpi4py.MPI.DISTRIBUTE_CYCLIC: int = DISTRIBUTE_CYCLIC`

Constant `DISTRIBUTE_CYCLIC` of type `int`

mpi4py.MPI.DISTRIBUTE_DFLT_DARG

`mpi4py.MPI.DISTRIBUTE_DFLT_DARG: int = DISTRIBUTE_DFLT_DARG`

Constant `DISTRIBUTE_DFLT_DARG` of type `int`

mpi4py.MPI.COMBINER_NAMED

`mpi4py.MPI.COMBINER_NAMED: int = COMBINER_NAMED`

Constant `COMBINER_NAMED` of type `int`

mpi4py.MPI.COMBINER_DUP

`mpi4py.MPI.COMBINER_DUP: int = COMBINER_DUP`

Constant `COMBINER_DUP` of type `int`

mpi4py.MPI.COMBINER_CONTIGUOUS

`mpi4py.MPI.COMBINER_CONTIGUOUS: int = COMBINER_CONTIGUOUS`

Constant `COMBINER_CONTIGUOUS` of type `int`

mpi4py.MPI.COMBINER_VECTOR

`mpi4py.MPI.COMBINER_VECTOR: int = COMBINER_VECTOR`

Constant `COMBINER_VECTOR` of type `int`

mpi4py.MPI.COMBINER_HVECTOR

`mpi4py.MPI.COMBINER_HVECTOR: int = COMBINER_HVECTOR`

Constant `COMBINER_HVECTOR` of type `int`

mpi4py.MPI.COMBINER_INDEXED

`mpi4py.MPI.COMBINER_INDEXED: int = COMBINER_INDEXED`

Constant `COMBINER_INDEXED` of type `int`

mpi4py.MPI.COMBINER_HINDEXED

`mpi4py.MPI.COMBINER_HINDEXED: int = COMBINER_HINDEXED`

Constant `COMBINER_HINDEXED` of type `int`

mpi4py.MPI.COMBINER_INDEXED_BLOCK

`mpi4py.MPI.COMBINER_INDEXED_BLOCK: int = COMBINER_INDEXED_BLOCK`

Constant `COMBINER_INDEXED_BLOCK` of type `int`

mpi4py.MPI.COMBINER_HINDEXED_BLOCK

`mpi4py.MPI.COMBINER_HINDEXED_BLOCK: int = COMBINER_HINDEXED_BLOCK`

Constant `COMBINER_HINDEXED_BLOCK` of type `int`

mpi4py.MPI.COMBINER_STRUCT

`mpi4py.MPI.COMBINER_STRUCT: int = COMBINER_STRUCT`

Constant `COMBINER_STRUCT` of type `int`

mpi4py.MPI.COMBINER_SUBARRAY

`mpi4py.MPI.COMBINER_SUBARRAY: int = COMBINER_SUBARRAY`

Constant COMBINER_SUBARRAY of type `int`

mpi4py.MPI.COMBINER_DARRAY

`mpi4py.MPI.COMBINER_DARRAY: int = COMBINER_DARRAY`

Constant COMBINER_DARRAY of type `int`

mpi4py.MPI.COMBINER_RESIZED

`mpi4py.MPI.COMBINER_RESIZED: int = COMBINER_RESIZED`

Constant COMBINER_RESIZED of type `int`

mpi4py.MPI.COMBINER_VALUE_INDEX

`mpi4py.MPI.COMBINER_VALUE_INDEX: int = COMBINER_VALUE_INDEX`

Constant COMBINER_VALUE_INDEX of type `int`

mpi4py.MPI.COMBINER_F90_INTEGER

`mpi4py.MPI.COMBINER_F90_INTEGER: int = COMBINER_F90_INTEGER`

Constant COMBINER_F90_INTEGER of type `int`

mpi4py.MPI.COMBINER_F90_REAL

`mpi4py.MPI.COMBINER_F90_REAL: int = COMBINER_F90_REAL`

Constant COMBINER_F90_REAL of type `int`

mpi4py.MPI.COMBINER_F90_COMPLEX

`mpi4py.MPI.COMBINER_F90_COMPLEX: int = COMBINER_F90_COMPLEX`

Constant COMBINER_F90_COMPLEX of type `int`

mpi4py.MPI.F_SOURCE

`mpi4py.MPI.F_SOURCE: int = F_SOURCE`

Constant F_SOURCE of type `int`

mpi4py.MPI.F_TAG

`mpi4py.MPI.F_TAG: int = F_TAG`

Constant F_TAG of type `int`

mpi4py.MPI.F_ERROR

`mpi4py.MPI.F_ERROR: int = F_ERROR`

Constant F_ERROR of type `int`

mpi4py.MPI.F_STATUS_SIZE

`mpi4py.MPI.F_STATUS_SIZE: int = F_STATUS_SIZE`

Constant F_STATUS_SIZE of type `int`

mpi4py.MPI.IDENT

`mpi4py.MPI.IDENT: int = IDENT`

Constant IDENT of type `int`

mpi4py.MPI.CONGRUENT

`mpi4py.MPI.CONGRUENT: int = CONGRUENT`

Constant CONGRUENT of type `int`

mpi4py.MPI.SIMILAR

`mpi4py.MPI.SIMILAR: int = SIMILAR`

Constant SIMILAR of type `int`

mpi4py.MPI.UNEQUAL

`mpi4py.MPI.UNEQUAL: int = UNEQUAL`

Constant UNEQUAL of type `int`

mpi4py.MPI.CART

`mpi4py.MPI.CART: int = CART`

Constant CART of type `int`

mpi4py.MPI.GRAPH

`mpi4py.MPI.GRAPH: int = GRAPH`

Constant GRAPH of type `int`

mpi4py.MPI.DIST_GRAPH

`mpi4py.MPI.DIST_GRAPH: int = DIST_GRAPH`

Constant DIST_GRAPH of type `int`

mpi4py.MPI.UNWEIGHTED

`mpi4py.MPI.UNWEIGHTED: int = UNWEIGHTED`

Constant UNWEIGHTED of type `int`

mpi4py.MPI.WEIGHTS_EMPTY

`mpi4py.MPI.WEIGHTS_EMPTY: int = WEIGHTS_EMPTY`

Constant WEIGHTS_EMPTY of type `int`

mpi4py.MPI.COMM_TYPE_SHARED

`mpi4py.MPI.COMM_TYPE_SHARED: int = COMM_TYPE_SHARED`

Constant COMM_TYPE_SHARED of type `int`

mpi4py.MPI.COMM_TYPE_HW_GUIDED

`mpi4py.MPI.COMM_TYPE_HW_GUIDED: int = COMM_TYPE_HW_GUIDED`

Constant COMM_TYPE_HW_GUIDED of type `int`

mpi4py.MPI.COMM_TYPE_HW_UNGUIDED

`mpi4py.MPI.COMM_TYPE_HW_UNGUIDED: int = COMM_TYPE_HW_UNGUIDED`

Constant `COMM_TYPE_HW_UNGUIDED` of type `int`

mpi4py.MPI.COMM_TYPE_RESOURCE_GUIDED

`mpi4py.MPI.COMM_TYPE_RESOURCE_GUIDED: int = COMM_TYPE_RESOURCE_GUIDED`

Constant `COMM_TYPE_RESOURCE_GUIDED` of type `int`

mpi4py.MPI.BSEND_OVERHEAD

`mpi4py.MPI.BSEND_OVERHEAD: int = BSEND_OVERHEAD`

Constant `BSEND_OVERHEAD` of type `int`

mpi4py.MPI.WIN_FLAVOR_CREATE

`mpi4py.MPI.WIN_FLAVOR_CREATE: int = WIN_FLAVOR_CREATE`

Constant `WIN_FLAVOR_CREATE` of type `int`

mpi4py.MPI.WIN_FLAVOR_ALLOCATE

`mpi4py.MPI.WIN_FLAVOR_ALLOCATE: int = WIN_FLAVOR_ALLOCATE`

Constant `WIN_FLAVOR_ALLOCATE` of type `int`

mpi4py.MPI.WIN_FLAVOR_DYNAMIC

`mpi4py.MPI.WIN_FLAVOR_DYNAMIC: int = WIN_FLAVOR_DYNAMIC`

Constant `WIN_FLAVOR_DYNAMIC` of type `int`

mpi4py.MPI.WIN_FLAVOR_SHARED

`mpi4py.MPI.WIN_FLAVOR_SHARED: int = WIN_FLAVOR_SHARED`

Constant `WIN_FLAVOR_SHARED` of type `int`

mpi4py.MPI.WIN_SEPARATE

`mpi4py.MPI.WIN_SEPARATE: int = WIN_SEPARATE`

Constant `WIN_SEPARATE` of type `int`

mpi4py.MPI.WIN_UNIFIED

`mpi4py.MPI.WIN_UNIFIED: int = WIN_UNIFIED`

Constant `WIN_UNIFIED` of type `int`

mpi4py.MPI.MODE_NOCHECK

`mpi4py.MPI.MODE_NOCHECK: int = MODE_NOCHECK`

Constant `MODE_NOCHECK` of type `int`

mpi4py.MPI.MODE_NOSTORE

`mpi4py.MPI.MODE_NOSTORE: int = MODE_NOSTORE`

Constant `MODE_NOSTORE` of type `int`

mpi4py.MPI.MODE_NOPUT

`mpi4py.MPI.MODE_NOPUT: int = MODE_NOPUT`

Constant `MODE_NOPUT` of type `int`

mpi4py.MPI.MODE_NOPRECEDE

`mpi4py.MPI.MODE_NOPRECEDE: int = MODE_NOPRECEDE`

Constant `MODE_NOPRECEDE` of type `int`

mpi4py.MPI.MODE_NOSUCCEED

`mpi4py.MPI.MODE_NOSUCCEED: int = MODE_NOSUCCEED`

Constant `MODE_NOSUCCEED` of type `int`

mpi4py.MPI.LOCK_EXCLUSIVE

`mpi4py.MPI.LOCK_EXCLUSIVE: int = LOCK_EXCLUSIVE`

Constant `LOCK_EXCLUSIVE` of type `int`

mpi4py.MPI.LOCK_SHARED

`mpi4py.MPI.LOCK_SHARED: int = LOCK_SHARED`

Constant `LOCK_SHARED` of type `int`

mpi4py.MPI.MODE_RDONLY

`mpi4py.MPI.MODE_RDONLY: int = MODE_RDONLY`

Constant `MODE_RDONLY` of type `int`

mpi4py.MPI.MODE_WRONLY

`mpi4py.MPI.MODE_WRONLY: int = MODE_WRONLY`

Constant `MODE_WRONLY` of type `int`

mpi4py.MPI.MODE_RDWR

`mpi4py.MPI.MODE_RDWR: int = MODE_RDWR`

Constant `MODE_RDWR` of type `int`

mpi4py.MPI.MODE_CREATE

`mpi4py.MPI.MODE_CREATE: int = MODE_CREATE`

Constant `MODE_CREATE` of type `int`

mpi4py.MPI.MODE_EXCL

`mpi4py.MPI.MODE_EXCL: int = MODE_EXCL`

Constant `MODE_EXCL` of type `int`

mpi4py.MPI.MODE_DELETE_ON_CLOSE

`mpi4py.MPI.MODE_DELETE_ON_CLOSE: int = MODE_DELETE_ON_CLOSE`

Constant `MODE_DELETE_ON_CLOSE` of type `int`

mpi4py.MPI.MODE_UNIQUE_OPEN

`mpi4py.MPI.MODE_UNIQUE_OPEN: int = MODE_UNIQUE_OPEN`

Constant `MODE_UNIQUE_OPEN` of type `int`

mpi4py.MPI.MODE_SEQUENTIAL

`mpi4py.MPI.MODE_SEQUENTIAL: int = MODE_SEQUENTIAL`

Constant `MODE_SEQUENTIAL` of type `int`

mpi4py.MPI.MODE_APPEND

`mpi4py.MPI.MODE_APPEND: int = MODE_APPEND`

Constant `MODE_APPEND` of type `int`

mpi4py.MPI.SEEK_SET

`mpi4py.MPI.SEEK_SET: int = SEEK_SET`

Constant `SEEK_SET` of type `int`

mpi4py.MPI.SEEK_CUR

`mpi4py.MPI.SEEK_CUR: int = SEEK_CUR`

Constant `SEEK_CUR` of type `int`

mpi4py.MPI.SEEK_END

`mpi4py.MPI.SEEK_END: int = SEEK_END`

Constant `SEEK_END` of type `int`

mpi4py.MPI.DISPLACEMENT_CURRENT

`mpi4py.MPI.DISPLACEMENT_CURRENT: int = DISPLACEMENT_CURRENT`

Constant `DISPLACEMENT_CURRENT` of type `int`

mpi4py.MPI.DISP_CUR

`mpi4py.MPI.DISP_CUR: int = DISP_CUR`

Constant `DISP_CUR` of type `int`

mpi4py.MPI.THREAD_SINGLE

`mpi4py.MPI.THREAD_SINGLE: int = THREAD_SINGLE`

Constant `THREAD_SINGLE` of type `int`

mpi4py.MPI.THREAD_FUNNELED

`mpi4py.MPI.THREAD_FUNNELED: int = THREAD_FUNNELED`

Constant `THREAD_FUNNELED` of type `int`

mpi4py.MPI.THREAD_SERIALIZED

`mpi4py.MPI.THREAD_SERIALIZED: int = THREAD_SERIALIZED`

Constant `THREAD_SERIALIZED` of type `int`

mpi4py.MPI.THREAD_MULTIPLE

`mpi4py.MPI.THREAD_MULTIPLE: int = THREAD_MULTIPLE`

Constant `THREAD_MULTIPLE` of type `int`

mpi4py.MPI.VERSION

`mpi4py.MPI.VERSION: int = VERSION`

Constant `VERSION` of type `int`

mpi4py.MPI.SUBVERSION

`mpi4py.MPI.SUBVERSION: int = SUBVERSION`

Constant `SUBVERSION` of type `int`

mpi4py.MPI.MAX_PROCESSOR_NAME

`mpi4py.MPI.MAX_PROCESSOR_NAME: int = MAX_PROCESSOR_NAME`

Constant `MAX_PROCESSOR_NAME` of type `int`

mpi4py.MPI.MAX_ERROR_STRING

`mpi4py.MPI.MAX_ERROR_STRING: int = MAX_ERROR_STRING`

Constant `MAX_ERROR_STRING` of type `int`

mpi4py.MPI.MAX_PORT_NAME

`mpi4py.MPI.MAX_PORT_NAME: int = MAX_PORT_NAME`

Constant `MAX_PORT_NAME` of type `int`

mpi4py.MPI.MAX_INFO_KEY

`mpi4py.MPI.MAX_INFO_KEY: int = MAX_INFO_KEY`

Constant `MAX_INFO_KEY` of type `int`

mpi4py.MPI.MAX_INFO_VAL

`mpi4py.MPI.MAX_INFO_VAL: int = MAX_INFO_VAL`

Constant `MAX_INFO_VAL` of type `int`

mpi4py.MPI.MAX_OBJECT_NAME

`mpi4py.MPI.MAX_OBJECT_NAME: int = MAX_OBJECT_NAME`

Constant `MAX_OBJECT_NAME` of type `int`

mpi4py.MPI.MAX_DATAREP_STRING

`mpi4py.MPI.MAX_DATAREP_STRING: int = MAX_DATAREP_STRING`

Constant `MAX_DATAREP_STRING` of type `int`

mpi4py.MPI.MAX_LIBRARY_VERSION_STRING

`mpi4py.MPI.MAX_LIBRARY_VERSION_STRING: int = MAX_LIBRARY_VERSION_STRING`

Constant `MAX_LIBRARY_VERSION_STRING` of type `int`

mpi4py.MPI.MAX_PSET_NAME_LEN

`mpi4py.MPI.MAX_PSET_NAME_LEN: int = MAX_PSET_NAME_LEN`

Constant `MAX_PSET_NAME_LEN` of type `int`

mpi4py.MPI.MAX_STRINGTAG_LEN

`mpi4py.MPI.MAX_STRINGTAG_LEN: int = MAX_STRINGTAG_LEN`

Constant `MAX_STRINGTAG_LEN` of type `int`

mpi4py.MPI.DATATYPE_NULL

`mpi4py.MPI.DATATYPE_NULL: Datatype = DATATYPE_NULL`

Object `DATATYPE_NULL` of type `Datatype`

mpi4py.MPI.PACKED

`mpi4py.MPI.PACKED: Datatype = PACKED`

Object `PACKED` of type `Datatype`

mpi4py.MPI.BYTE

`mpi4py.MPI.BYTE: Datatype = BYTE`

Object `BYTE` of type `Datatype`

mpi4py.MPI.AINT

`mpi4py.MPI.AINT: Datatype = AINT`

Object `AINT` of type `Datatype`

mpi4py.MPI.OFFSET

`mpi4py.MPI.OFFSET: Datatype = OFFSET`

Object `OFFSET` of type `Datatype`

mpi4py.MPI.COUNT

`mpi4py.MPI.COUNT: Datatype = COUNT`

Object `COUNT` of type `Datatype`

mpi4py.MPI.CHAR

`mpi4py.MPI.CHAR: Datatype = CHAR`

Object `CHAR` of type `Datatype`

mpi4py.MPI.WCHAR

`mpi4py.MPI.WCHAR: Datatype = WCHAR`

Object `WCHAR` of type `Datatype`

mpi4py.MPI.SIGNED_CHAR

`mpi4py.MPI.SIGNED_CHAR: Datatype = SIGNED_CHAR`

Object `SIGNED_CHAR` of type `Datatype`

mpi4py.MPI.SHORT

`mpi4py.MPI.SHORT: Datatype = SHORT`

Object SHORT of type *Datatype*

mpi4py.MPI.INT

`mpi4py.MPI.INT: Datatype = INT`

Object INT of type *Datatype*

mpi4py.MPI.LONG

`mpi4py.MPI.LONG: Datatype = LONG`

Object LONG of type *Datatype*

mpi4py.MPI.LONG_LONG

`mpi4py.MPI.LONG_LONG: Datatype = LONG_LONG`

Object LONG_LONG of type *Datatype*

mpi4py.MPI.UNSIGNED_CHAR

`mpi4py.MPI.UNSIGNED_CHAR: Datatype = UNSIGNED_CHAR`

Object UNSIGNED_CHAR of type *Datatype*

mpi4py.MPI.UNSIGNED_SHORT

`mpi4py.MPI.UNSIGNED_SHORT: Datatype = UNSIGNED_SHORT`

Object UNSIGNED_SHORT of type *Datatype*

mpi4py.MPI.UNSIGNED

`mpi4py.MPI.UNSIGNED: Datatype = UNSIGNED`

Object UNSIGNED of type *Datatype*

mpi4py.MPI.UNSIGNED_LONG

`mpi4py.MPI.UNSIGNED_LONG: Datatype = UNSIGNED_LONG`

Object UNSIGNED_LONG of type *Datatype*

mpi4py.MPI.UNSIGNED_LONG_LONG

`mpi4py.MPI.UNSIGNED_LONG_LONG: Datatype = UNSIGNED_LONG_LONG`

Object UNSIGNED_LONG_LONG of type *Datatype*

mpi4py.MPI.FLOAT

`mpi4py.MPI.FLOAT: Datatype = FLOAT`

Object FLOAT of type *Datatype*

mpi4py.MPI.DOUBLE

`mpi4py.MPI.DOUBLE: Datatype = DOUBLE`

Object DOUBLE of type *Datatype*

mpi4py.MPI.LONG_DOUBLE

`mpi4py.MPI.LONG_DOUBLE`: *Datatype* = LONG_DOUBLE

Object LONG_DOUBLE of type *Datatype*

mpi4py.MPI.C_BOOL

`mpi4py.MPI.C_BOOL`: *Datatype* = C_BOOL

Object C_BOOL of type *Datatype*

mpi4py.MPI.INT8_T

`mpi4py.MPI.INT8_T`: *Datatype* = INT8_T

Object INT8_T of type *Datatype*

mpi4py.MPI.INT16_T

`mpi4py.MPI.INT16_T`: *Datatype* = INT16_T

Object INT16_T of type *Datatype*

mpi4py.MPI.INT32_T

`mpi4py.MPI.INT32_T`: *Datatype* = INT32_T

Object INT32_T of type *Datatype*

mpi4py.MPI.INT64_T

`mpi4py.MPI.INT64_T`: *Datatype* = INT64_T

Object INT64_T of type *Datatype*

mpi4py.MPI.UINT8_T

`mpi4py.MPI.UINT8_T`: *Datatype* = UINT8_T

Object UINT8_T of type *Datatype*

mpi4py.MPI.UINT16_T

`mpi4py.MPI.UINT16_T`: *Datatype* = UINT16_T

Object UINT16_T of type *Datatype*

mpi4py.MPI.UINT32_T

`mpi4py.MPI.UINT32_T`: *Datatype* = UINT32_T

Object UINT32_T of type *Datatype*

mpi4py.MPI.UINT64_T

`mpi4py.MPI.UINT64_T`: *Datatype* = UINT64_T

Object UINT64_T of type *Datatype*

mpi4py.MPI.FLOAT16_T

`mpi4py.MPI.FLOAT16_T`: *Datatype* = FLOAT16_T

Object FLOAT16_T of type *Datatype*

mpi4py.MPI.FLOAT32_T

`mpi4py.MPI.FLOAT32_T`: *Datatype* = `Float32_T`

Object `Float32_T` of type *Datatype*

mpi4py.MPI.FLOAT64_T

`mpi4py.MPI.FLOAT64_T`: *Datatype* = `Float64_T`

Object `Float64_T` of type *Datatype*

mpi4py.MPI.BFLOAT16_T

`mpi4py.MPI.BFLOAT16_T`: *Datatype* = `BFloat16_T`

Object `BFloat16_T` of type *Datatype*

mpi4py.MPI.C_COMPLEX

`mpi4py.MPI.C_COMPLEX`: *Datatype* = `C_COMPLEX`

Object `C_COMPLEX` of type *Datatype*

mpi4py.MPI.C_FLOAT_COMPLEX

`mpi4py.MPI.C_FLOAT_COMPLEX`: *Datatype* = `C_FLOAT_COMPLEX`

Object `C_FLOAT_COMPLEX` of type *Datatype*

mpi4py.MPI.C_DOUBLE_COMPLEX

`mpi4py.MPI.C_DOUBLE_COMPLEX`: *Datatype* = `C_DOUBLE_COMPLEX`

Object `C_DOUBLE_COMPLEX` of type *Datatype*

mpi4py.MPI.C_LONG_DOUBLE_COMPLEX

`mpi4py.MPI.C_LONG_DOUBLE_COMPLEX`: *Datatype* = `C_LONG_DOUBLE_COMPLEX`

Object `C_LONG_DOUBLE_COMPLEX` of type *Datatype*

mpi4py.MPI.CXX_BOOL

`mpi4py.MPI.CXX_BOOL`: *Datatype* = `CXX_BOOL`

Object `CXX_BOOL` of type *Datatype*

mpi4py.MPI.CXX_FLOAT_COMPLEX

`mpi4py.MPI.CXX_FLOAT_COMPLEX`: *Datatype* = `CXX_FLOAT_COMPLEX`

Object `CXX_FLOAT_COMPLEX` of type *Datatype*

mpi4py.MPI.CXX_DOUBLE_COMPLEX

`mpi4py.MPI.CXX_DOUBLE_COMPLEX`: *Datatype* = `CXX_DOUBLE_COMPLEX`

Object `CXX_DOUBLE_COMPLEX` of type *Datatype*

mpi4py.MPI.CXX_LONG_DOUBLE_COMPLEX

`mpi4py.MPI.CXX_LONG_DOUBLE_COMPLEX`: *Datatype* = `CXX_LONG_DOUBLE_COMPLEX`

Object `CXX_LONG_DOUBLE_COMPLEX` of type *Datatype*

mpi4py.MPI.SHORT_INT

`mpi4py.MPI.SHORT_INT: Datatype = SHORT_INT`

Object `SHORT_INT` of type *Datatype*

mpi4py.MPI.INT_INT

`mpi4py.MPI.INT_INT: Datatype = INT_INT`

Object `INT_INT` of type *Datatype*

mpi4py.MPI.TWOINT

`mpi4py.MPI.TWOINT: Datatype = TWOINT`

Object `TWOINT` of type *Datatype*

mpi4py.MPI.LONG_INT

`mpi4py.MPI.LONG_INT: Datatype = LONG_INT`

Object `LONG_INT` of type *Datatype*

mpi4py.MPI.FLOAT_INT

`mpi4py.MPI.FLOAT_INT: Datatype = FLOAT_INT`

Object `FLOAT_INT` of type *Datatype*

mpi4py.MPI.DOUBLE_INT

`mpi4py.MPI.DOUBLE_INT: Datatype = DOUBLE_INT`

Object `DOUBLE_INT` of type *Datatype*

mpi4py.MPI.LONG_DOUBLE_INT

`mpi4py.MPI.LONG_DOUBLE_INT: Datatype = LONG_DOUBLE_INT`

Object `LONG_DOUBLE_INT` of type *Datatype*

mpi4py.MPI.CHARACTER

`mpi4py.MPI.CHARACTER: Datatype = CHARACTER`

Object `CHARACTER` of type *Datatype*

mpi4py.MPI.LOGICAL

`mpi4py.MPI.LOGICAL: Datatype = LOGICAL`

Object `LOGICAL` of type *Datatype*

mpi4py.MPI.INTEGER

`mpi4py.MPI.INTEGER: Datatype = INTEGER`

Object `INTEGER` of type *Datatype*

mpi4py.MPI.REAL

`mpi4py.MPI.REAL: Datatype = REAL`

Object `REAL` of type *Datatype*

mpi4py.MPI.DOUBLE_PRECISION

`mpi4py.MPI.DOUBLE_PRECISION`: *Datatype* = DOUBLE_PRECISION

Object DOUBLE_PRECISION of type *Datatype*

mpi4py.MPI.COMPLEX

`mpi4py.MPI.COMPLEX`: *Datatype* = COMPLEX

Object COMPLEX of type *Datatype*

mpi4py.MPI.DOUBLE_COMPLEX

`mpi4py.MPI.DOUBLE_COMPLEX`: *Datatype* = DOUBLE_COMPLEX

Object DOUBLE_COMPLEX of type *Datatype*

mpi4py.MPI.LOGICAL1

`mpi4py.MPI.LOGICAL1`: *Datatype* = LOGICAL1

Object LOGICAL1 of type *Datatype*

mpi4py.MPI.LOGICAL2

`mpi4py.MPI.LOGICAL2`: *Datatype* = LOGICAL2

Object LOGICAL2 of type *Datatype*

mpi4py.MPI.LOGICAL4

`mpi4py.MPI.LOGICAL4`: *Datatype* = LOGICAL4

Object LOGICAL4 of type *Datatype*

mpi4py.MPI.LOGICAL8

`mpi4py.MPI.LOGICAL8`: *Datatype* = LOGICAL8

Object LOGICAL8 of type *Datatype*

mpi4py.MPI.LOGICAL16

`mpi4py.MPI.LOGICAL16`: *Datatype* = LOGICAL16

Object LOGICAL16 of type *Datatype*

mpi4py.MPI.INTEGER1

`mpi4py.MPI.INTEGER1`: *Datatype* = INTEGER1

Object INTEGER1 of type *Datatype*

mpi4py.MPI.INTEGER2

`mpi4py.MPI.INTEGER2`: *Datatype* = INTEGER2

Object INTEGER2 of type *Datatype*

mpi4py.MPI.INTEGER4

`mpi4py.MPI.INTEGER4`: *Datatype* = INTEGER4

Object INTEGER4 of type *Datatype*

mpi4py.MPI.INTEGER8

`mpi4py.MPI.INTEGER8`: *Datatype* = `INTEGER8`

Object `INTEGER8` of type *Datatype*

mpi4py.MPI.INTEGER16

`mpi4py.MPI.INTEGER16`: *Datatype* = `INTEGER16`

Object `INTEGER16` of type *Datatype*

mpi4py.MPI.REAL2

`mpi4py.MPI.REAL2`: *Datatype* = `REAL2`

Object `REAL2` of type *Datatype*

mpi4py.MPI.REAL4

`mpi4py.MPI.REAL4`: *Datatype* = `REAL4`

Object `REAL4` of type *Datatype*

mpi4py.MPI.REAL8

`mpi4py.MPI.REAL8`: *Datatype* = `REAL8`

Object `REAL8` of type *Datatype*

mpi4py.MPI.REAL16

`mpi4py.MPI.REAL16`: *Datatype* = `REAL16`

Object `REAL16` of type *Datatype*

mpi4py.MPI.COMPLEX4

`mpi4py.MPI.COMPLEX4`: *Datatype* = `COMPLEX4`

Object `COMPLEX4` of type *Datatype*

mpi4py.MPI.COMPLEX8

`mpi4py.MPI.COMPLEX8`: *Datatype* = `COMPLEX8`

Object `COMPLEX8` of type *Datatype*

mpi4py.MPI.COMPLEX16

`mpi4py.MPI.COMPLEX16`: *Datatype* = `COMPLEX16`

Object `COMPLEX16` of type *Datatype*

mpi4py.MPI.COMPLEX32

`mpi4py.MPI.COMPLEX32`: *Datatype* = `COMPLEX32`

Object `COMPLEX32` of type *Datatype*

mpi4py.MPI.UNSIGNED_INT

`mpi4py.MPI.UNSIGNED_INT`: *Datatype* = `UNSIGNED_INT`

Object `UNSIGNED_INT` of type *Datatype*

mpi4py.MPI.SIGNED_SHORT

`mpi4py.MPI.SIGNED_SHORT`: *Datatype* = SIGNED_SHORT

Object SIGNED_SHORT of type *Datatype*

mpi4py.MPI.SIGNED_INT

`mpi4py.MPI.SIGNED_INT`: *Datatype* = SIGNED_INT

Object SIGNED_INT of type *Datatype*

mpi4py.MPI.SIGNED_LONG

`mpi4py.MPI.SIGNED_LONG`: *Datatype* = SIGNED_LONG

Object SIGNED_LONG of type *Datatype*

mpi4py.MPI.SIGNED_LONG_LONG

`mpi4py.MPI.SIGNED_LONG_LONG`: *Datatype* = SIGNED_LONG_LONG

Object SIGNED_LONG_LONG of type *Datatype*

mpi4py.MPI.BOOL

`mpi4py.MPI.BOOL`: *Datatype* = BOOL

Object BOOL of type *Datatype*

mpi4py.MPI.SINT8_T

`mpi4py.MPI.SINT8_T`: *Datatype* = SINT8_T

Object SINT8_T of type *Datatype*

mpi4py.MPI.SINT16_T

`mpi4py.MPI.SINT16_T`: *Datatype* = SINT16_T

Object SINT16_T of type *Datatype*

mpi4py.MPI.SINT32_T

`mpi4py.MPI.SINT32_T`: *Datatype* = SINT32_T

Object SINT32_T of type *Datatype*

mpi4py.MPI.SINT64_T

`mpi4py.MPI.SINT64_T`: *Datatype* = SINT64_T

Object SINT64_T of type *Datatype*

mpi4py.MPI.F_BOOL

`mpi4py.MPI.F_BOOL`: *Datatype* = F_BOOL

Object F_BOOL of type *Datatype*

mpi4py.MPI.F_INT

`mpi4py.MPI.F_INT`: *Datatype* = F_INT

Object F_INT of type *Datatype*

mpi4py.MPI.F_FLOAT

`mpi4py.MPI.F_FLOAT`: *Datatype* = F_FLOAT

Object F_FLOAT of type *Datatype*

mpi4py.MPI.F_DOUBLE

`mpi4py.MPI.F_DOUBLE`: *Datatype* = F_DOUBLE

Object F_DOUBLE of type *Datatype*

mpi4py.MPI.F_COMPLEX

`mpi4py.MPI.F_COMPLEX`: *Datatype* = F_COMPLEX

Object F_COMPLEX of type *Datatype*

mpi4py.MPI.F_FLOAT_COMPLEX

`mpi4py.MPI.F_FLOAT_COMPLEX`: *Datatype* = F_FLOAT_COMPLEX

Object F_FLOAT_COMPLEX of type *Datatype*

mpi4py.MPI.F_DOUBLE_COMPLEX

`mpi4py.MPI.F_DOUBLE_COMPLEX`: *Datatype* = F_DOUBLE_COMPLEX

Object F_DOUBLE_COMPLEX of type *Datatype*

mpi4py.MPI.REQUEST_NULL

`mpi4py.MPI.REQUEST_NULL`: *Request* = REQUEST_NULL

Object REQUEST_NULL of type *Request*

mpi4py.MPI.MESSAGE_NULL

`mpi4py.MPI.MESSAGE_NULL`: *Message* = MESSAGE_NULL

Object MESSAGE_NULL of type *Message*

mpi4py.MPI.MESSAGE_NO_PROC

`mpi4py.MPI.MESSAGE_NO_PROC`: *Message* = MESSAGE_NO_PROC

Object MESSAGE_NO_PROC of type *Message*

mpi4py.MPI.OP_NULL

`mpi4py.MPI.OP_NULL`: *Op* = OP_NULL

Object OP_NULL of type *Op*

Parameters

- *x* (*Any*)
- *y* (*Any*)

Return type

Any

mpi4py.MPI.MAX

`mpi4py.MPI.MAX`: *Op* = **MAX**

Object MAX of type *Op*

Parameters

- **x** (*Any*)
- **y** (*Any*)

Return type

Any

mpi4py.MPI.MIN

`mpi4py.MPI.MIN`: *Op* = **MIN**

Object MIN of type *Op*

Parameters

- **x** (*Any*)
- **y** (*Any*)

Return type

Any

mpi4py.MPI.SUM

`mpi4py.MPI.SUM`: *Op* = **SUM**

Object SUM of type *Op*

Parameters

- **x** (*Any*)
- **y** (*Any*)

Return type

Any

mpi4py.MPI.PROD

`mpi4py.MPI.PROD`: *Op* = **PROD**

Object PROD of type *Op*

Parameters

- **x** (*Any*)
- **y** (*Any*)

Return type

Any

mpi4py.MPI.LAND

`mpi4py.MPI.LAND`: *Op* = **LAND**

Object LAND of type *Op*

Parameters

- **x** (*Any*)
- **y** (*Any*)

Return type

Any

mpi4py.MPI.BAND

`mpi4py.MPI.BAND`: *Op* = BAND

Object BAND of type *Op*

Parameters

- **x** (*Any*)
- **y** (*Any*)

Return type

Any

mpi4py.MPI.LOR

`mpi4py.MPI.LOR`: *Op* = LOR

Object LOR of type *Op*

Parameters

- **x** (*Any*)
- **y** (*Any*)

Return type

Any

mpi4py.MPI.BOR

`mpi4py.MPI.BOR`: *Op* = BOR

Object BOR of type *Op*

Parameters

- **x** (*Any*)
- **y** (*Any*)

Return type

Any

mpi4py.MPI.LXOR

`mpi4py.MPI.LXOR`: *Op* = LXOR

Object LXOR of type *Op*

Parameters

- **x** (*Any*)
- **y** (*Any*)

Return type

Any

mpi4py.MPI.BXOR

`mpi4py.MPI.BXOR`: *Op* = **BXOR**

Object BXOR of type *Op*

Parameters

- **x** (*Any*)
- **y** (*Any*)

Return type

Any

mpi4py.MPI.MAXLOC

`mpi4py.MPI.MAXLOC`: *Op* = **MAXLOC**

Object MAXLOC of type *Op*

Parameters

- **x** (*Any*)
- **y** (*Any*)

Return type

Any

mpi4py.MPI.MINLOC

`mpi4py.MPI.MINLOC`: *Op* = **MINLOC**

Object MINLOC of type *Op*

Parameters

- **x** (*Any*)
- **y** (*Any*)

Return type

Any

mpi4py.MPI.REPLACE

`mpi4py.MPI.REPLACE`: *Op* = **REPLACE**

Object REPLACE of type *Op*

Parameters

- **x** (*Any*)
- **y** (*Any*)

Return type

Any

mpi4py.MPI.NO_OP

`mpi4py.MPI.NO_OP`: *Op* = **NO_OP**

Object NO_OP of type *Op*

Parameters

- *x* (*Any*)
- *y* (*Any*)

Return type

Any

mpi4py.MPI.GROUP_NULL

mpi4py.MPI.GROUP_NULL: *Group* = GROUP_NULL

Object GROUP_NULL of type *Group*

mpi4py.MPI.GROUP_EMPTY

mpi4py.MPI.GROUP_EMPTY: *Group* = GROUP_EMPTY

Object GROUP_EMPTY of type *Group*

mpi4py.MPI.INFO_NULL

mpi4py.MPI.INFO_NULL: *Info* = INFO_NULL

Object INFO_NULL of type *Info*

mpi4py.MPI.INFO_ENV

mpi4py.MPI.INFO_ENV: *Info* = INFO_ENV

Object INFO_ENV of type *Info*

mpi4py.MPI.ERRHANDLER_NULL

mpi4py.MPI.ERRHANDLER_NULL: *Errhandler* = ERRHANDLER_NULL

Object ERRHANDLER_NULL of type *Errhandler*

mpi4py.MPI.ERRORS_RETURN

mpi4py.MPI.ERRORS_RETURN: *Errhandler* = ERRORS_RETURN

Object ERRORS_RETURN of type *Errhandler*

mpi4py.MPI.ERRORS_ABORT

mpi4py.MPI.ERRORS_ABORT: *Errhandler* = ERRORS_ABORT

Object ERRORS_ABORT of type *Errhandler*

mpi4py.MPI.ERRORS_ARE_FATAL

mpi4py.MPI.ERRORS_ARE_FATAL: *Errhandler* = ERRORS_ARE_FATAL

Object ERRORS_ARE_FATAL of type *Errhandler*

mpi4py.MPI.SESSION_NULL

mpi4py.MPI.SESSION_NULL: *Session* = SESSION_NULL

Object SESSION_NULL of type *Session*

mpi4py.MPI.COMM_NULL

`mpi4py.MPI.COMM_NULL`: *Comm* = COMM_NULL

Object COMM_NULL of type *Comm*

mpi4py.MPI.COMM_SELF

`mpi4py.MPI.COMM_SELF`: *Intracomm* = COMM_SELF

Object COMM_SELF of type *Intracomm*

mpi4py.MPI.COMM_WORLD

`mpi4py.MPI.COMM_WORLD`: *Intracomm* = COMM_WORLD

Object COMM_WORLD of type *Intracomm*

mpi4py.MPI.WIN_NULL

`mpi4py.MPI.WIN_NULL`: *Win* = WIN_NULL

Object WIN_NULL of type *Win*

mpi4py.MPI.FILE_NULL

`mpi4py.MPI.FILE_NULL`: *File* = FILE_NULL

Object FILE_NULL of type *File*

mpi4py.MPI.BOTTOM

`mpi4py.MPI.BOTTOM`: *BottomType* = BOTTOM

Object BOTTOM of type *BottomType*

mpi4py.MPI.IN_PLACE

`mpi4py.MPI.IN_PLACE`: *InPlaceType* = IN_PLACE

Object IN_PLACE of type *InPlaceType*

mpi4py.MPI.BUFFER_AUTOMATIC

`mpi4py.MPI.BUFFER_AUTOMATIC`: *BufferAutomaticType* = BUFFER_AUTOMATIC

Object BUFFER_AUTOMATIC of type *BufferAutomaticType*

mpi4py.MPI.pickle

`mpi4py.MPI.pickle`: *Pickle* = <mpi4py.MPI.Pickle object>

Object pickle of type *Pickle*

12 Citation

If MPI for Python been significant to a project that leads to an academic publication, please acknowledge that fact by citing the project.

- M. Rogowski, S. Aseeri, D. Keyes, and L. Dalcin, *mpi4py.futures: MPI-Based Asynchronous Task Execution for Python*, IEEE Transactions on Parallel and Distributed Systems, 34(2):611-622, 2023. <https://doi.org/10.1109/TPDS.2022.3225481>

- L. Dalcin and Y.-L. L. Fang, *mpi4py: Status Update After 12 Years of Development*, Computing in Science & Engineering, 23(4):47-54, 2021. <https://doi.org/10.1109/MCSE.2021.3083216>
- L. Dalcin, P. Kler, R. Paz, and A. Cosimo, *Parallel Distributed Computing using Python*, Advances in Water Resources, 34(9):1124-1139, 2011. <https://doi.org/10.1016/j.advwatres.2011.04.013>
- L. Dalcin, R. Paz, M. Storti, and J. D'Elia, *MPI for Python: performance improvements and MPI-2 extensions*, Journal of Parallel and Distributed Computing, 68(5):655-662, 2008. <https://doi.org/10.1016/j.jpdc.2007.09.005>
- L. Dalcin, R. Paz, and M. Storti, *MPI for Python*, Journal of Parallel and Distributed Computing, 65(9):1108-1115, 2005. <https://doi.org/10.1016/j.jpdc.2005.03.010>

13 Installation

13.1 Wheel packages

The mpi4py project builds and publishes binary wheels able to run in a variety of:

- operating systems: *Linux, macOS, Windows*;
- processor architectures: *AMD64, ARM64*;
- MPI implementations: *MPICH, Open MPI, MVAPICH, Intel MPI, HPE Cray MPICH, Microsoft MPI*;
- Python implementations: *CPython, PyPy*.

These mpi4py wheels are distributed via the Python Package Index (PyPI) and can be installed with Python package managers like `pip`:

```
python -m pip install mpi4py
```

The mpi4py wheels can be installed in standard Python virtual environments. The MPI runtime can be provided by other wheels installed in the same virtual environment.

Tip

Intel publishes production-grade [Intel MPI wheels](#) for Linux (x86_64) and Windows (AMD64). mpi4py and MPI wheels can be installed side by side to get a ready-to-use Python+MPI environment:

```
python -m pip install mpi4py impi-rt
```

Tip

The mpi4py project publishes [MPICH wheels](#) and [Open MPI wheels](#) for Linux (x86_64/aarch64) and macOS (arm64/x86_64). mpi4py and MPI wheels can be installed side by side to get a ready-to-use Python+MPI environment:

```
python -m pip install mpi4py mpich # for MPICH
python -m pip install mpi4py openmpi # for Open MPI
```

Warning

The MPI wheels are distributed with special focus on ease of use, convenience, compatibility, and interoperability. The Linux wheels are built in somewhat constrained environments with relatively dated Linux distributions ([manylinux](#) container images). Therefore, they may lack support for features like GPU awareness (CUDA/ROCm) and C++/Fortran bindings. In production scenarios, it is recommended to use external (either custom-built or system-provided) MPI installations.

The `mpi4py` wheels can also be installed (with `pip`) in `conda` environments and they should work out of the box, without any special tweak to environment variables, for any of the MPI packages provided by `conda-forge`.

Externally-provided MPI implementations may come from a system package manager, sysadmin-maintained builds accessible via module files, or customized user builds. Such usage is supported and encouraged. However, there are a few platform-specific considerations to take into account.

Linux

The Linux (x86_64/aarch64) wheels require one of

- [MPICH](#) or any other ABI-compatible derivative, like [MVAPICH](#), [Intel MPI](#), [HPE Cray MPICH](#)
- [Open MPI](#) or any other ABI-compatible derivative, like [NVIDIA HPC-X](#)

Users may need to set the `LD_LIBRARY_PATH` environment variable such that the dynamic linker is able to find at runtime the MPI shared library file (`libmpi.so.*`).

Fedora/RHEL

On Fedora/RHEL systems, both `MPICH` and `Open MPI` are available for installation. There is no default or preferred MPI implementation. Instead, users must select their favorite MPI implementation by loading the proper MPI module.

```
module load mpi/mpich-$(arch)    # for MPICH
module load mpi/openmpi-$(arch) # for Open MPI
```

After loading the requested MPI module, the `LD_LIBRARY_PATH` environment variable should be properly setup.

Debian/Ubuntu

On Debian/Ubuntu systems, `Open MPI` is the default MPI implementation and most of the MPI-based applications and libraries provided by the distribution depend on `Open MPI`. Nonetheless, `MPICH` is also available to users for installation.

In Ubuntu 22.04 and older, due to legacy reasons, the `MPICH` ABI is slightly broken: the MPI shared library file is named `libmpich.so.12` instead of `libmpi.so.12` as required by the [MPICH ABI Compatibility Initiative](#).

Users without `sudo` access can workaround this issue creating a symbolic link anywhere in their home directory and appending to `LD_LIBRARY_PATH`.

```
mkdir -p ~/.local/lib
libdir=/usr/lib/$(arch)-linux-gnu
ln -s $libdir/libmpich.so.12 ~/.local/lib/libmpi.so.12
export LD_LIBRARY_PATH=$LD_LIBRARY_PATH:~/.local/lib
```

A system-wide fix for all users requires `sudo` access:

```
libdir=/usr/lib/$(arch)-linux-gnu
sudo ln -sr $libdir/libmpi{ch,}.so.12
```

HPE Cray OS

On HPE Cray systems, users must load the `cray-mpich-abi` module. For further details, refer to `man intro_mpi`.

macOS

The macOS (arm64/x86_64) wheels require

- [MPICH](#) or [Open MPI](#) installed (either manually or via a package manager) in the standard system prefix `/usr/local`
- [MPICH](#) or [Open MPI](#) installed via [Homebrew](#) in the default prefix `/opt/homebrew`
- [MPICH](#) or [Open MPI](#) installed via [MacPorts](#) in the default prefix `/opt/local`

Windows

The Windows (AMD64) wheels require one of

- [Intel MPI](#)
- [Microsoft MPI](#)

User may need to set the `I_MPI_ROOT` or `MSMPI_BIN` environment variables such that the MPI dynamic link library (DLL) (`impi.dll` or `msmpi.dll`) can be found at runtime.

Intel MPI is under active development and supports recent versions of the MPI standard. Intel MPI can be installed with `pip` (see the `impi-rt` package on PyPI), being therefore straightforward to get it up and running within a Python environment. Intel MPI can also be installed system-wide as part of the Intel oneAPI HPC Toolkit for Windows or via standalone online/offline installers.

13.2 Conda packages

The [conda-forge](#) community provides ready-to-use binary packages from an ever growing collection of software libraries built around the multi-platform `conda` package manager. Four MPI implementations are available on `conda-forge`: [Open MPI](#) (Linux and macOS), [MPICH](#) (Linux and macOS), [Intel MPI](#) (Linux and Windows), and [Microsoft MPI](#) (Windows). You can install `mpi4py` and your preferred MPI implementation using the `conda` package manager:

- to use [MPICH](#) do:

```
conda install -c conda-forge mpi4py mpich
```

- to use [Open MPI](#) do:

```
conda install -c conda-forge mpi4py openmpi
```

- to use [Intel MPI](#) do:

```
conda install -c conda-forge mpi4py impi_rt
```

- to use [Microsoft MPI](#) do:

```
conda install -c conda-forge mpi4py msmapi
```

MPICH and many of its derivatives are ABI-compatible. You can provide the package specification `mpich=X.Y.*=external_*` (where X and Y are the major and minor version numbers) to request the conda package manager to use system-provided MPICH (or derivative) libraries. Similarly, you can provide the package specification `openmpi=X.Y.*=external_*` to use system-provided Open MPI libraries.

The `openmpi` package on conda-forge has built-in CUDA support, but it is disabled by default. To enable it, follow the instruction outlined during `conda install`. Additionally, UCX support is also available once the `ucx` package is installed.

Warning

The MPI conda-forge packages are built with special focus on compatibility. The MPICH and Open MPI packages are built in a constrained environment with relatively dated OS images. Therefore, they may lack support for high-performance features like cross-memory attach (XPMEM/CMA). In production scenarios, it is recommended to use external (either custom-built or system-provided) MPI installations. See the relevant conda-forge documentation about [using external MPI libraries](#).

13.3 System packages

`mpi4py` is readily available through system package managers of most Linux distributions and the most popular community package managers for macOS.

Linux

On **Fedora Linux** systems (as well as **RHEL** and their derivatives using the EPEL software repository), you can install binary packages with the system package manager:

- using `dnf` and the `mpich` package:

```
sudo dnf install python3-mpi4py-mpich
```

- using `dnf` and the `openmpi` package:

```
sudo dnf install python3-mpi4py-openmpi
```

Please remember to load the correct MPI module for your chosen MPI implementation:

- for the `mpich` package do:

```
module load mpi/mpich-$(arch)
python -c "from mpi4py import MPI"
```

- for the `openmpi` package do:

```
module load mpi/openmpi-$(arch)
python -c "from mpi4py import MPI"
```

On **Ubuntu Linux** and **Debian Linux** systems, binary packages are available for installation using the system package manager:

```
sudo apt install python3-mpi4py
```

On **Arch Linux** systems, binary packages are available for installation using the system package manager:

```
sudo pacman -S python-mpi4py
```

macOS

macOS users can install mpi4py using the [Homebrew](#) package manager:

```
brew install mpi4py
```

Note that the Homebrew mpi4py package uses Open MPI. Alternatively, install the `mpich` package and next install mpi4py from sources using `pip`.

Alternatively, mpi4py can be installed from [MacPorts](#):

```
sudo port install py-mpi4py
```

13.4 Building from sources

Installing mpi4py from pre-built binary wheels, conda packages, or system packages is not always desired or appropriate. For example, the mpi4py wheels published on PyPI may not be interoperable with non-mainstream, vendor-specific MPI implementations; or a system mpi4py package may be built with an alternative, non-default MPI implementation. In such scenarios, mpi4py can still be installed from its source distribution (sdist) using `pip`:

```
python -m pip install --no-binary=mpi4py mpi4py
```

You can also install the in-development version with:

```
python -m pip install git+https://github.com/mpi4py/mpi4py
```

or:

```
python -m pip install https://github.com/mpi4py/mpi4py/tarball/master
```

Note

Installing mpi4py from its source distribution (available on PyPI) or Git source code repository (available on GitHub) requires a C compiler and a working MPI implementation with development headers and libraries.

Warning

`pip` keeps previously built wheel files in its cache for future reuse. If you want to reinstall the `mpi4py` package from its source distribution using a different or updated MPI implementation, you have to either first remove the cached wheel file:

```
python -m pip cache remove mpi4py
python -m pip install --no-binary=mpi4py mpi4py
```

or ask `pip` to disable the cache:

```
python -m pip install --no-cache-dir --no-binary=mpi4py mpi4py
```

13.5 Build backends

mpi4py supports three different build backends: `setuptools` (default), `scikit-build-core` (CMake-based), and `meson-python` (Meson-based). The build backend can be selected by setting the `MPI4PY_BUILD_BACKEND` environment variable.

MPI4PY_BUILD_BACKEND

Choices

"setuptools", "scikit-build-core", "meson-python"

Default

"setuptools"

Request a build backend for building mpi4py from sources.

Using setuptools

Tip

Set the `MPI4PY_BUILD_BACKEND` environment variable to "setuptools" to use the `setuptools` build backend.

When using the default `setuptools` build backend, `mpi4py` relies on the legacy Python distutils framework to build C extension modules. The following environment variables affect the build configuration.

MPI4PY_BUILD_MPICC

The `mpicc` compiler wrapper command is searched for in the executable search path (`PATH` environment variable) and used to compile the `mpi4py.MPI` C extension module. Alternatively, use the `MPI4PY_BUILD_MPICC` environment variable to the full path or command corresponding to the MPI-aware C compiler.

MPI4PY_BUILD_MPILD

The `mpicc` compiler wrapper command is also used for linking the `mpi4py.MPI` C extension module. Alternatively, use the `MPI4PY_BUILD_MPILD` environment variable to specify the full path or command corresponding to the MPI-aware C linker.

MPI4PY_BUILD_MPICFG

If the MPI implementation does not provide a compiler wrapper, or it is not installed in a default system location, all relevant build information like include/library locations and library lists can be provided in an ini-style configuration file under a `[mpi]` section. `mpi4py` can then be asked to use the custom build information by setting the `MPI4PY_BUILD_MPICFG` environment variable to the full path of the configuration file. As an example, see the `mpi.cfg` file located in the top level `mpi4py` source directory.

MPI4PY_BUILD_CONFIGURE

Some vendor MPI implementations may not provide complete coverage of the MPI standard, or may provide partial features of newer MPI standard versions while advertising support for an older version. Setting the `MPI4PY_BUILD_CONFIGURE` environment variable to a non-empty string will trigger the run of exhaustive checks for the availability of all MPI constants, predefined handles, and routines.

MPI4PY_BUILD_MPIABI

Setting the `MPI4PY_BUILD_MPIABI` environment variable to "1" enables enhanced support for the MPI 5.0 standard ABI and the MPICH or Open MPI legacy ABIs. The `mpi4py.MPI` extension module is then able to dynamically link at runtime with older versions (down to the MPI 3.0 standard) of the corresponding MPI implementation used at compile time. This feature is only available on Linux, macOS, and Windows. POSIX-like systems other than Linux and macOS are not currently supported, although they could easily be: all what is needed is for the platform to either support weak symbols in shared modules/libraries, or support the standard POSIX `dlopen()/dlsym()` APIs.

MPI4PY_BUILD_PYSABI

Build with the CPython 3.10+ Stable ABI. Setting the `MPI4PY_BUILD_PYSABI` environment variable to a string "{major}.{minor}" defines the `Py_LIMITED_API` value to use for building extension modules.

The following environment variables are aliases for the ones described above. Having shorter names, they are convenient for occasional use in the command line. Its usage is not recommended in automation scenarios like packaging recipes, deployment scripts, and container image creation.

MPICC

Convenience alias for `MPI4PY_BUILD_MPICC`.

MPILD

Convenience alias for `MPI4PY_BUILD_MPILD`.

MPICFG

Convenience alias for `MPI4PY_BUILD_MPICFG`.

Using scikit-build-core

Tip

Set the `MPI4PY_BUILD_BACKEND` environment variable to "scikit-build-core" to use the `scikit-build-core` build backend.

When using the `scikit-build-core` build backend, `mpi4py` delegates all of MPI build configuration to CMake's `FindMPI` module. Besides the obvious advantage of cross-platform support, this delegation to CMake may be convenient in build environments exposing vendor software stacks via intricate module systems. Note however that `mpi4py` will not be able to look for MPI routines available beyond the MPI standard version the MPI implementation advertises to support (via the `MPI_VERSION` and `MPI_SUBVERSION` macro constants in the `mpi.h` header file), any missing MPI constant or symbol will prevent a successful build.

Using meson-python

Tip

Set the `MPI4PY_BUILD_BACKEND` environment variable to "meson-python" to use the `meson-python` build backend.

When using the `meson-python` build backend, `mpi4py` delegates build tasks to the `Meson` build system.

Warning

`mpi4py` support for the `meson-python` build backend is experimental. For the time being, users must set the `CC` environment variable to the command or path corresponding to the `mpicc` C compiler wrapper.

14 Development

14.1 Prerequisites

You need to have the following software properly installed to develop *MPI for Python*:

- Python 3.8 or above.
- The `Cython` compiler.
- A working MPI implementation like `MPICH` or `Open MPI`, preferably supporting MPI-4 and built with shared/dynamic libraries.

Optionally, consider installing the following packages:

- NumPy for enabling comprehensive testing of MPI communication.
- CuPy for enabling comprehensive testing with a GPU-aware MPI.
- Sphinx to build the documentation.

 **Tip**

Most routine development tasks like building, installing in editable mode, testing, and generating documentation can be performed with the `spin` developer tool. Run `spin` at the top level source directory for a list of available subcommands.

14.2 Building

MPI for Python uses `setuptools`-based build system that relies on the `setup.py` file. Some `setuptools` commands (e.g., `build`) accept additional options:

--mpi=

Lets you pass a section with MPI configuration within a special configuration file. Alternatively, you can use the `MPICFG` environment variable.

--mpicc=

Specify the path or name of the `mpicc` C compiler wrapper. Alternatively, use the `MPICC` environment variable.

--mpild=

Specify the full path or name for the MPI-aware C linker. Alternatively, use the `MPILD` environment variable. If not set, the `mpicc` C compiler wrapper is used for linking.

--configure

Runs exhaustive tests for checking about missing MPI types, constants, and functions. This option should be passed in order to build *MPI for Python* against old MPI-1, MPI-2, or MPI-3 implementations, possibly providing a subset of MPI-4.

If you use a MPI implementation providing a `mpicc` C compiler wrapper (e.g., MPICH or Open MPI), it will be used for compilation and linking. This is the preferred and easiest way to build *MPI for Python*.

If `mpicc` is found in the executable search path (PATH environment variable), simply run the `build` command:

```
$ python setup.py build
```

If `mpicc` is not in your search path or the compiler wrapper has a different name, you can run the `build` command specifying its location, either via the `--mpicc` command option or using the `MPICC` environment variable:

```
$ python setup.py build --mpicc=/path/to/mpicc
$ env MPICC=/path/to/mpicc python setup.py build
```

Alternatively, you can provide all the relevant information about your MPI implementation by editing the `mpi.cfg` file located in the top level source directory. You can use the default section `[mpi]` or add a new custom section, for example `[vendor_mpi]` (see the examples provided in the `mpi.cfg` file as a starting point to write your own section):

```
[mpi]
include_dirs      = /usr/local/mpi/include
libraries         = mpi
library_dirs      = /usr/local/mpi/lib
runtime_library_dirs = /usr/local/mpi/lib
```

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```
[vendor_mpi]
include_dirs      = /opt/mpi/include ...
libraries         = mpi ...
library_dirs     = /opt/mpi/lib ...
runtime_library_dirs = /opt/mpi/lib ...
...
```

and then run the *build* command specifying you custom configuration section:

```
$ python setup.py build --mpi=vendor_mpi
$ env MPICFG=vendor_mpi python setup.py build
```

14.3 Installing

MPI for Python can be installed in editable mode:

```
$ python -m pip install --editable .
```

After modifying Cython sources, an in-place rebuild is needed:

```
$ python setup.py build --inplace
```

14.4 Testing

To quickly test the installation:

```
$ mpiexec -n 5 python -m mpi4py.bench helloworld
Hello, World! I am process 0 of 5 on localhost.
Hello, World! I am process 1 of 5 on localhost.
Hello, World! I am process 2 of 5 on localhost.
Hello, World! I am process 3 of 5 on localhost.
Hello, World! I am process 4 of 5 on localhost.

$ mpiexec -n 5 python -m mpi4py.bench ringtest -l 10 -n 1048576
time for 10 loops = 0.00361614 seconds (5 processes, 1048576 bytes)
```

If you installed from a git clone or the source distribution, issuing at the command line:

```
$ mpiexec -n 5 python demo/helloworld.py
```

will launch a five-process run of the Python interpreter and run the demo script `demo/helloworld.py` from the source distribution.

You can also run all the *unittest* scripts:

```
$ mpiexec -n 5 python test/main.py
```

or, if you have the *pytest* unit testing framework installed:

```
$ mpiexec -n 5 pytest
```

15 Guidelines

15.1 Fair play

Summary

This section defines Rules of Play for companies and outside developers that engage with the mpi4py project. It covers:

- Restrictions on use of the mpi4py name.
- How and whether to publish a modified distribution.
- How to make us aware of patched versions.

After reading this section, companies and developers will know what kinds of behavior the mpi4py developers and contributors would like to see, and which we consider troublesome, bothersome, and unacceptable.

This document is a close adaptation of [NumPy NEP 36](#).

Motivation

Occasionally, we learn of modified mpi4py versions and binary distributions circulated by outsiders. These patched versions can cause problems to mpi4py users (see, e.g., [mpi4py/mpi4py#508](#)). When issues like these arise, our developers waste time identifying the problematic release, locating alterations, and determining an appropriate course of action.

In addition, packages on the Python Packaging Index are sometimes named such that users assume they are sanctioned or maintained by the mpi4py developers. We wish to reduce the number of such incidents.

Scope

This document aims to define a minimal set of rules that, when followed, will be considered good-faith efforts in line with the expectations of the mpi4py developers and contributors.

Our hope is that companies and outside developers who feel they need to modify mpi4py will first consider contributing to the project, or use alternative mechanisms for patching and extending mpi4py.

When in doubt, please [talk to us first](#). We may suggest an alternative; at minimum, we'll be informed and we may even grant an exception if deemed appropriate.

Fair play rules

1. Do not reuse the mpi4py name for projects not affiliated with the mpi4py project.

At time of writing, there are only a handful of mpi4py-named packages developed by the mpi4py project, including `mpi4py` and `mpi4py-fft`. We ask that outside packages not include the phrase `mpi4py`, i.e., avoid names such as `mycompany-mpi4py` or `mpi4py-mycompany`.

To be clear, this rule only applies to modules (package names); it is perfectly acceptable to have a *submodule* of your own package named `mycompany.mpi4py`.

2. Do not publish binary mpi4py wheels on PyPI (<https://pypi.org/>).

We ask companies and outside developers to not publish binary mpi4py wheels in the main Python Package Index (<https://pypi.org/>) under names such as `mpi4py-mpich`, `mpi4py-openmpi`, or `mpi4py-vendor_mpi`.

The usual approaches to build binary Python wheels involve the embedding of dependent shared libraries. While such an approach may seem convenient and often is, in the particular case of MPI and mpi4py it is ultimately harmful to end users. Embedding the MPI shared libraries would prevent the use of external, system-provided MPI installations with hardware-specific optimizations and site-specific tweaks.

The MPI 5.0 standard features an Application Binary Interface (ABI) for MPI, see [mpi-abi-paper] and [mpi-abi-issue]. Such standardization allows for any binary dependent on the MPI library to be used with multiple MPI backends. Once MPI implementations provide support for the new MPI ABI, the mpi4py project will follow and add support to the binary wheels published on PyPI.

3. Do not republish modified versions of mpi4py.

Modified versions of mpi4py make it very difficult for the developers to address bug reports, since we typically do not know which parts of mpi4py have been modified.

If you have to break this rule (and we implore you not to!), then make it clear in the `__version__` tag that you have modified mpi4py, e.g.:

```
>>> print(mpi4py.__version__)  
'4.0.0+mycompany.13'
```

We understand that minor patches are often required to make a library work inside of a package ecosystem. This is totally acceptable, but we ask that no substantive changes are made.

4. Do not extend or modify mpi4py's API.

If you absolutely have to break the previous rule, please do not add additional functions to the namespace, or modify the API of existing functions. Having additional functions exposed in distributed versions is confusing for users and developers alike.

16 LICENSE

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17 CHANGES

17.1 Release 4.1.2 [2026-05-16]

- Fix build issues from breaking changes in setuptools 81.
- Support Windows builds with Meson and Intel MPI.

- PyPy wheels are no longer published.

17.2 Release 4.1.1 [2025-10-10]

- Add MPIABI-aware import hook support.
- Support `MPI.ERR_ERRHANDLER` with Open MPI.
- Fix Windows build issues with Intel MPI 2021.16.
- Minor fixes and improvements to typing stubs.
- Minor fixes to documentation.
- Publish Python 3.8-3.14 and PyPy 3.11 wheels.
- PyPy 3.10 (EOL) wheels are no longer published.

17.3 Release 4.1.0 [2025-06-25]

- New features:
 - Publish binary wheel packages on [PyPI](#) with support for multiple operating systems (Linux, macOS, Windows), processor architectures (AMD64, ARM64), MPI implementations (MPICH, Open MPI, and their ABI-compatible derivatives), and Python implementations (CPython, PyPy).
 - Add support for the MPI 5.0 standard.
 - * MPI handle serialization with integral values.
 - * Fixed-size Fortran LOGICAL datatypes.
 - * Query ABI version/info and Fortran ABI info.
 - `MPI.Datatype.Create_contiguous` now uses [BigMPI](#)'s approach when using MPI implementations that do not yet support the MPI 4.0 large-count APIs.
 - Add support for `MPI.FLOAT16_T` and `MPI.BFLOAT16_T` datatypes. These datatypes are not yet standard but available as extensions in MPI implementations.
 - Add `MPI.Status.tomemory` to expose the status contents as a `memoryview` object.
- Enhancements:
 - Support (opt-in via `MPI4PY_BUILD_PYSABI`) for building with `Py_LIMITED_API` under Python 3.10+ (requires Cython 3.1+).
 - Support (opt-in via `MPI4PY_BUILD_MPIABI`) for building with the MPI 5.0 standard ABI and the MPICH or Open MPI legacy ABIs. The `MPI` extension module will be able to dynamically link at runtime with older versions (down to the MPI 3.0 standard) of the MPI implementation used at compile time. Only available on Linux, macOS, and Windows.
 - Support a `buffer_size` parameter in the `MPIPoolExecutor.map()` and `MPIPoolExecutor.starmap()` methods to limit the number of pending tasks.
 - Improve ownership management of DLPack capsules.
 - Reimplement MPI DLL search path on Windows.
 - Minor fixes to typing stubs and documentation.
- Backward-incompatible changes:
 - Python 3.8+ is required.
 - The `MPI.Exception` class is now a heap type.

- The types of the `MPI.BOTTOM`, `MPI.IN_PLACE`, and `MPI.BUFFER_AUTOMATIC` are no longer subclasses of `int`.

17.4 Release 4.0.3 [2025-02-13]

- Fix DLPack v1.0 support.

17.5 Release 4.0.2 [2025-02-01]

- Support MPI-4 features within Intel MPI 2021.14.
- Various fixes and updates to tests.
- Minor fixes to typing support.
- Minor fix to documentation.

17.6 Release 4.0.1 [2024-10-11]

- Update support for Python 3.13:
 - Enable Cython 3.1 support for free-threaded CPython.
 - Allow compiling Cython-generated C sources with the full Python C-API.
 - Fix MPI DLL path workarounds on Windows after changes to `locals()`.
- Enhancements to test suite:
 - Support XML reports via `unittest-xml-reporting`.
 - Add command line options to exclude tests by patterns and files.
 - Refactor Python 2 code to use Python 3 constructs using `pyupgrade`.
- Miscellaneous:
 - Minor and mostly inconsequential subclass fix in `mpi4py.util.pkl5`.
 - Update compatibility workarounds for legacy MPICH 3.0 release.

17.7 Release 4.0.0 [2024-07-28]

- New features:
 - Add support for the MPI-4.0 standard.
 - * Use large count MPI-4 routines.
 - * Add persistent collective communication.
 - * Add partitioned point-to-point communication.
 - * Add new communicator constructors.
 - * Add the `Session` class and its methods.
 - Add support for the MPI-4.1 standard.
 - * Add non-destructive completion test for multiple requests.
 - * Add value-index datatype constructor.
 - * Add communicator/session buffer attach/detach/flush.
 - * Support for removal of error classes/codes/strings.

- * Support for querying hardware resource information.
 - Add preliminary support for the upcoming MPI-5.0 standard.
 - * User-level failure mitigation (ULFM).
 - `mpi4py.util.pool`: New drop-in replacement for `multiprocessing.pool`.
 - `mpi4py.util.sync`: New synchronization utilities.
 - Add runtime check for mismatch between `mpiexec` and MPI library.
 - Support `scikit-build-core` as an alternative build backend.
 - Support `meson-python` as an alternative build backend.
- Enhancements:
 - `mpi4py.futures`: Support for parallel tasks.
 - `mpi4py.futures`: Report exception tracebacks in workers.
 - `mpi4py.util.pk15`: Add support for collective communication.
 - Add methods `Datatype.fromcode()`, `Datatype.tocode()` and attributes `Datatype.typestr`, `Datatype.typechar` to simplify NumPy interoperability for simple cases.
 - Add methods `Comm.Create_errhandler()`, `Win.Create_errhandler()`, and `File.Create_errhandler()` to create custom error handlers.
 - Add support for pickle serialization of instances of MPI types. All instances of `Datatype`, `Info`, and `Status` can be serialized. Instances of `Op` can be serialized only if created through `mpi4py` by calling `Op.Create()`. Instances of other MPI types can be serialized only if they reference predefined handles.
 - Add `handle` attribute and `fromhandle()` class method to MPI classes to ease interoperability with external code. The `handle` value is an unsigned integer guaranteed to fit on the platform's `uintptr_t` C type.
 - Add lowercase `free()` method to MPI classes to ease MPI object deallocation and cleanup. This method eventually attempts to call `Free()`, but only if the object's MPI handle is not a null or predefined handle, and such call is allowed within the World Model `init/finalize`.
 - Backward-incompatible changes:
 - Python 2 is no longer supported, Python 3.6+ is required, but typing stubs are supported for Python 3.8+.
 - The `Intracomm.Create_group()` method is no longer defined in the base `Comm` class.
 - `Group.Compare()` and `Comm.Compare()` are no longer class methods but instance methods. Existing codes using the former class methods are expected to continue working.
 - `Group.Translate_ranks()` is no longer a class method but an instance method. Existing codes using the former class method are expected to continue working.
 - The LB and UB datatypes are no longer available, use `Datatype.Create_resized()` instead.
 - The `HOST` predefined attribute key is no longer available.
 - The `MPI.memory` class has been renamed to `MPI.buffer`. The old name is still available as an alias to the new name.
 - The `mpi4py.dl` module is no longer available.
 - The `mpi4py.get_config` function returns an empty dictionary.
 - Miscellaneous:

- The project is now licensed under the BSD-3-Clause license. This change is fairly inconsequential for users and distributors. It simply adds an additional clause against using contributor names for promotional purposes without their consent.
- Add a new guidelines section to documentation laying out new fair play rules. These rules ask companies and outside developers to refrain from reusing the `mpi4py` name in unaffiliated projects, publishing binary `mpi4py` wheels on the main Python Package Index (PyPI), and distributing modified versions with incompatible or extended API changes. The primary motivation of these rules is to avoid fragmentation and end-user confusion.

17.8 Release 3.1.6 [2024-04-14]

Warning

This is the last release supporting Python 2.

- Fix various build issues.

17.9 Release 3.1.5 [2023-10-04]

Warning

This is the last release supporting Python 2.

- Rebuild C sources with Cython 0.29.36 to support Python 3.12.

17.10 Release 3.1.4 [2022-11-02]

Warning

This is the last release supporting Python 2.

- Rebuild C sources with Cython 0.29.32 to support Python 3.11.
- Fix contiguity check for `DLPack` and `CAI` buffers.
- Workaround build failures with `setuptools` v60.

17.11 Release 3.1.3 [2021-11-25]

Warning

This is the last release supporting Python 2.

- Add missing support for `MPI_BOTTOM` to generalized all-to-all collectives.

17.12 Release 3.1.2 [2021-11-04]

Warning

This is the last release supporting Python 2.

- `mpi4py.futures`: Add `_max_workers` property to `MPIPoolExecutor`.
- `mpi4py.util.dtlib`: Fix computation of alignment for predefined datatypes.
- `mpi4py.util.pkl5`: Fix deadlock when using `ssend()` + `mprobe()`.
- `mpi4py.util.pkl5`: Add environment variable `MPI4PY_PICKLE_THRESHOLD`.
- `mpi4py.rc`: Interpret "y" and "n" strings as boolean values.
- Fix/add `typemap/typestr` for `MPI.WCHAR/MPI.COUNT` datatypes.
- Minor fixes and additions to documentation.
- Minor fixes to typing support.
- Support for local version identifier (PEP-440).

17.13 Release 3.1.1 [2021-08-14]

Warning

This is the last release supporting Python 2.

- Fix typo in `Requires-Python` package metadata.
- Regenerate C sources with Cython 0.29.24.

17.14 Release 3.1.0 [2021-08-12]

Warning

This is the last release supporting Python 2.

- New features:
 - `mpi4py.util`: New package collecting miscellaneous utilities.
- Enhancements:
 - Add pickle-based `Request.waitsome()` and `Request.testsome()`.
 - Add lowercase methods `Request.get_status()` and `Request.cancel()`.
 - Support for passing Python GPU arrays compliant with the [DLPack](#) data interchange mechanism ([link](#)) and the `__cuda_array_interface__` (CAI) standard ([link](#)) to uppercase methods. This support requires that `mpi4py` is built against [CUDA-aware MPI](#) implementations. This feature is currently experimental and subject to future changes.
 - `mpi4py.futures`: Add support for initializers and canceling futures at shutdown. Environment variables names now follow the pattern `MPI4PY_FUTURES_*`, the previous `MPI4PY_*` names are deprecated.

- Add type annotations to Cython code. The first line of the docstring of functions and methods displays a signature including type annotations.
- Add companion stub files to support type checkers.
- Support for weak references.
- Miscellaneous:
 - Add a new mpi4py publication ([link](#)) to the citation listing.

17.15 Release 3.0.3 [2019-11-04]

- Regenerate Cython wrappers to support Python 3.8.

17.16 Release 3.0.2 [2019-06-11]

- Bug fixes:
 - Fix handling of readonly buffers in support for Python 2 legacy buffer interface. The issue triggers only when using a buffer-like object that is readonly and does not export the new Python 3 buffer interface.
 - Fix build issues with Open MPI 4.0.x series related to removal of many MPI-1 symbols deprecated in MPI-2 and removed in MPI-3.
 - Minor documentation fixes.

17.17 Release 3.0.1 [2019-02-15]

- Bug fixes:
 - Fix `Comm.scatter()` and other collectives corrupting input send list. Add safety measures to prevent related issues in global reduction operations.
 - Fix error-checking code for counts in `Op.Reduce_local()`.
- Enhancements:
 - Map size-specific Python/NumPy typecodes to MPI datatypes.
 - Allow partial specification of target list/tuple arguments in the various `Win` RMA methods.
 - Workaround for removal of `MPI_{LB|UB}` in Open MPI 4.0.
 - Support for Microsoft MPI v10.0.

17.18 Release 3.0.0 [2017-11-08]

- New features:
 - `mpi4py.futures`: Execute computations asynchronously using a pool of MPI processes. This package is based on `concurrent.futures` from the Python standard library.
 - `mpi4py.run`: Run Python code and abort execution in case of unhandled exceptions to prevent deadlocks.
 - `mpi4py.bench`: Run basic MPI benchmarks and tests.
- Enhancements:
 - Lowercase, pickle-based collective communication calls are now thread-safe through the use of fine-grained locking.
 - The `MPI` module now exposes a `memory` type which is a lightweight variant of the builtin `memoryview` type, but exposes both the legacy Python 2 and the modern Python 3 buffer interface under a Python 2 runtime.

- The `MPI.Comm.Alltoallw()` method now uses `count=1` and `displ=0` as defaults, assuming that messages are specified through user-defined datatypes.
- The `Request.Wait[all]()` methods now return `True` to match the interface of `Request.Test[all]()`.
- The `Win` class now implements the Python buffer interface.
- Backward-incompatible changes:
 - The `buf` argument of the `MPI.Comm.recv()` method is deprecated, passing anything but `None` emits a warning.
 - The `MPI.Win.memory` property was removed, use the `MPI.Win.tomemory()` method instead.
 - Executing `python -m mpi4py` in the command line is now equivalent to `python -m mpi4py.run`. For the former behavior, use `python -m mpi4py.bench`.
 - Python 2.6 and 3.2 are no longer supported. The `mpi4py.MPI` module may still build and partially work, but other pure-Python modules under the `mpi4py` namespace will not.
 - Windows: Remove support for legacy MPICH2, Open MPI, and DeinoMPI.

17.19 Release 2.0.0 [2015-10-18]

- Support for MPI-3 features.
 - Matched probes and receives.
 - Nonblocking collectives.
 - Neighborhood collectives.
 - New communicator constructors.
 - Request-based RMA operations.
 - New RMA communication and synchronisation calls.
 - New window constructors.
 - New datatype constructor.
 - New C++ boolean and floating complex datatypes.
- Support for MPI-2 features not included in previous releases.
 - Generalized All-to-All collective (`Comm.Alltoallw()`)
 - User-defined data representations (`Register_datarep()`)
- New scalable implementation of reduction operations for Python objects. This code is based on binomial tree algorithms using point-to-point communication and duplicated communicator contexts. To disable this feature, use `mpi4py.rc.fast_reduce = False`.
- Backward-incompatible changes:
 - Python 2.4, 2.5, 3.0 and 3.1 are no longer supported.
 - Default MPI error handling policies are overridden. After import, `mpi4py` sets the `ERRORS_RETURN` error handler in `COMM_SELF` and `COMM_WORLD`, as well as any new `Comm`, `Win`, or `File` instance created through `mpi4py`, thus effectively ignoring the MPI rules about error handler inheritance. This way, MPI errors translate to Python exceptions. To disable this behavior and use the standard MPI error handling rules, use `mpi4py.rc.errors = 'default'`.
 - Change signature of all send methods, `dest` is a required argument.

- Change signature of all receive and probe methods, `source` defaults to `ANY_SOURCE`, `tag` defaults to `ANY_TAG`.
- Change signature of send lowercase-spelling methods, `obj` arguments are not mandatory.
- Change signature of `recv` lowercase-spelling methods, renamed `'obj'` arguments to `'buf'`.
- Change `Request.Waitosome()` and `Request.Testosome()` to return `None` or `list`.
- Change signature of all lowercase-spelling collectives, `sendobj` arguments are now mandatory, `recvobj` arguments were removed.
- Reduction operations `MAXLOC` and `MINLOC` are no longer special-cased in lowercase-spelling methods `Comm.[all]reduce()` and `Comm.[ex]scan()`, the input object must be specified as a tuple (`obj`, `location`).
- Change signature of name publishing functions. The new signatures are `Publish_name(service_name, port_name, info=INFO_NULL)` and `Unpublish_name(service_name, port_name, info=INFO_NULL)`.
- `Win` instances now cache Python objects exposing memory by keeping references instead of using MPI attribute caching.
- Change signature of `Win.Lock()`. The new signature is `Win.Lock(rank, lock_type=LOCK_EXCLUSIVE, assertion=0)`.
- Move `Cartcomm.Map()` to `Intracomm.Cart_map()`.
- Move `Graphcomm.Map()` to `Intracomm.Graph_map()`.
- Remove the `mpi4py.MPE` module.
- Rename the Cython definition file for use with `cimport` statement from `mpi_c.pxd` to `libmpi.pxd`.

17.20 Release 1.3.1 [2013-08-07]

- Regenerate C wrappers with Cython 0.19.1 to support Python 3.3.
- Install `*.pxd` files in `<site-packages>/mpi4py` to ease the support for Cython's `cimport` statement in code requiring to access `mpi4py` internals.
- As a side-effect of using Cython 0.19.1, ancient Python 2.3 is no longer supported. If you really need it, you can install an older Cython and run `python setup.py build_src --force`.

17.21 Release 1.3 [2012-01-20]

- Now `Comm.recv()` accept a buffer to receive the message.
- Add `Comm.irecv()` and `Request.{wait|test}[any|all]()`.
- Add `Intracomm.Spawn_multiple()`.
- Better buffer handling for PEP 3118 and legacy buffer interfaces.
- Add support for attribute caching on communicators, datatypes and windows.
- Install MPI-enabled Python interpreter as `<path>/mpi4py/bin/python-mpi`.
- Windows: Support for building with Open MPI.

17.22 Release 1.2.2 [2010-09-13]

- Add `mpi4py.get_config()` to retrieve information (compiler wrappers, includes, libraries, etc) about the MPI implementation employed to build `mpi4py`.
- Workaround Python libraries with missing GILState-related API calls in case of non-threaded Python builds.
- Windows: look for MPICH2, DeinoMPI, Microsoft HPC Pack at their default install locations under `%Program-Files`.
- MPE: fix hacks related to old API's, these hacks are broken when MPE is built with a MPI implementations other than MPICH2.
- HP-MPI: fix for missing Fortran datatypes, use `dlopen()` to load the MPI shared library before `MPI_Init()`
- Many distutils-related fixes, cleanup, and enhancements, better logics to find MPI compiler wrappers.
- Support for `pip install mpi4py`.

17.23 Release 1.2.1 [2010-02-26]

- Fix declaration in Cython include file. This declaration, while valid for Cython, broke the simple-minded parsing used in `conf/mpidistutils.py` to implement `configure-tests` for availability of MPI symbols.
- Update SWIG support and make it compatible with Python 3. Also generate an warning for SWIG < 1.3.28.
- Fix distutils-related issues in Mac OS X. Now `ARCHFLAGS` environment variable is honored of all Python's `config/Makefile` variables.
- Fix issues with Open MPI < 1.4.2 related to error checking and `MPI_XXX_NULL` handles.

17.24 Release 1.2 [2009-12-29]

- Automatic MPI datatype discovery for NumPy arrays and PEP-3118 buffers. Now buffer-like objects can be messaged directly, it is no longer required to explicitly pass a 2/3-list/tuple like `[data, MPI.DOUBLE]`, or `[data, count, MPI.DOUBLE]`. Only basic types are supported, i.e., all C/C99-native signed/unsigned integral types and single/double precision real/complex floating types. Many thanks to Eilif Muller for the initial feedback.
- Nonblocking send of pickled Python objects. Many thanks to Andreas Kloeckner for the initial patch and enlightening discussion about this enhancement.
- `Request` instances now hold a reference to the Python object exposing the buffer involved in point-to-point communication or parallel I/O. Many thanks to Andreas Kloeckner for the initial feedback.
- Support for logging of user-defined states and events using `MPE.Runtime` (i.e., without requiring a recompile!) activation of logging of all MPI calls is supported in POSIX platforms implementing `dlopen()`.
- Support for all the new features in MPI-2.2 (new C99 and F90 datatypes, distributed graph topology, local reduction operation, and other minor enhancements).
- Fix the annoying issues related to Open MPI and Python dynamic loading of extension modules in platforms supporting `dlopen()`.
- Fix SLURM dynamic loading issues on SiCortex. Many thanks to Ian Langmore for providing me shell access.

17.25 Release 1.1.0 [2009-06-06]

- Fix bug in `Comm.Iprobe()` that caused segfaults as Python C-API calls were issued with the GIL released (issue #2).
- Add `Comm.bsend()` and `Comm.ssend()` for buffered and synchronous send semantics when communicating general Python objects.

- Now the call `Info.Get(key)` return a *single* value (i.e, instead of a 2-tuple); this value is `None` if `key` is not in the `Info` object, or a string otherwise. Previously, the call redundantly returned `(None, False)` for missing key-value pairs; `None` is enough to signal a missing entry.
- Add support for parametrized Fortran datatypes.
- Add support for decoding user-defined datatypes.
- Add support for user-defined reduction operations on memory buffers. However, at most 16 user-defined reduction operations can be created. Ask the author for more room if you need it.

17.26 Release 1.0.0 [2009-03-20]

This is the first release of the all-new, Cython-based, implementation of *MPI for Python*. Unfortunately, this implementation is not backward-compatible with the previous one. The list below summarizes the more important changes that can impact user codes.

- Some communication calls had *overloaded* functionality. Now there is a clear distinction between communication of general Python object with *pickle*, and (fast, near C-speed) communication of buffer-like objects (e.g., NumPy arrays).
 - for communicating general Python objects, you have to use all-lowercase methods, like `send()`, `recv()`, `bcast()`, etc.
 - for communicating array data, you have to use `Send()`, `Recv()`, `Bcast()`, etc. methods. Buffer arguments to these calls must be explicitly specified by using a 2/3-list/tuple like `[data, MPI.DOUBLE]`, or `[data, count, MPI.DOUBLE]` (the former one uses the byte-size of `data` and the extent of the MPI datatype to define the count).
- Indexing a communicator with an integer returned a special object associating the communication with a target rank, alleviating you from specifying source/destination/root arguments in point-to-point and collective communications. This functionality is no longer available, expressions like:

```
MPI.COMM_WORLD[0].Send(...)
MPI.COMM_WORLD[0].Recv(...)
MPI.COMM_WORLD[0].Bcast(...)
```

have to be replaced by:

```
MPI.COMM_WORLD.Send(..., dest=0)
MPI.COMM_WORLD.Recv(..., source=0)
MPI.COMM_WORLD.Bcast(..., root=0)
```

- Automatic MPI initialization (i.e., at import time) requests the maximum level of MPI thread support (i.e., it is done by calling `MPI_Init_thread()` and passing `MPI_THREAD_MULTIPLE`). In case you need to change this behavior, you can tweak the contents of the `mpi4py.rc` module.
- In order to obtain the values of predefined attributes attached to the world communicator, now you have to use the `Get_attr()` method on the `MPI.COMM_WORLD` instance:

```
tag_ub = MPI.COMM_WORLD.Get_attr(MPI.TAG_UB)
```

- In the previous implementation, `MPI.COMM_WORLD` and `MPI.COMM_SELF` were associated to **duplicates** of the (C-level) `MPI_COMM_WORLD` and `MPI_COMM_SELF` predefined communicator handles. Now this is no longer the case, `MPI.COMM_WORLD` and `MPI.COMM_SELF` proxies the **actual** `MPI_COMM_WORLD` and `MPI_COMM_SELF` handles.
- Convenience aliases `MPI.WORLD` and `MPI.SELF` were removed. Use instead `MPI.COMM_WORLD` and `MPI.COMM_SELF`.

- Convenience constants `MPI.WORLD_SIZE` and `MPI.WORLD_RANK` were removed. Use instead `MPI.COMM_WORLD.Get_size()` and `MPI.COMM_WORLD.Get_rank()`.

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