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# MPI for Python

*Release 4.0.1*

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**November 19, 2024**

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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, MATLAB<sup>1</sup> 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.

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<sup>1</sup> MATLAB is a registered trademark of The MathWorks, Inc.

- 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**
  - 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.Get_group` 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.Create_group`.

New communicator instances can be obtained with the `Comm.Clone`, `Comm.Dup` and `Comm.Split` methods, as well methods `Intracomm.Create_intercomm` 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.Create_cart` and `Intracomm.Create_graph`.

## 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. Additionally, collective functions come in blocking versions only.

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
```

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```

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()

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

```

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```
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)

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
```

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```
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],
            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()
```

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```
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

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

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

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

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```

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)
itemsizesize = datatype.Get_size()

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

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)
    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.

**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**  
`bool`

**Default**  
`True`

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, *, 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>Prerequest</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>
<i>ROOT</i>	Constant ROOT of type <i>int</i>
<i>BOTTOM</i>	Constant BOTTOM of type <i>BottomType</i>
<i>IN_PLACE</i>	Constant IN_PLACE of type <i>InPlaceType</i>
<i>BUFFER_AUTOMATIC</i>	Constant BUFFER_AUTOMATIC of type <i>BufferAutomaticType</i>
<i>KEYVAL_INVALID</i>	Constant KEYVAL_INVALID of type <i>int</i>
<i>TAG_UB</i>	Constant TAG_UB of type <i>int</i>
<i>IO</i>	Constant IO of type <i>int</i>
<i>WTIME_IS_GLOBAL</i>	Constant WTIME_IS_GLOBAL of type <i>int</i>
<i>UNIVERSE_SIZE</i>	Constant UNIVERSE_SIZE of type <i>int</i>
<i>APPNUM</i>	Constant APPNUM of type <i>int</i>
<i>LASTUSEDPCODE</i>	Constant LASTUSEDPCODE of type <i>int</i>
<i>WIN_BASE</i>	Constant WIN_BASE of type <i>int</i>
<i>WIN_SIZE</i>	Constant WIN_SIZE of type <i>int</i>
<i>WIN_DISP_UNIT</i>	Constant WIN_DISP_UNIT of type <i>int</i>
<i>WIN_CREATE_FLAVOR</i>	Constant WIN_CREATE_FLAVOR of type <i>int</i>
<i>WIN_FLAVOR</i>	Constant WIN_FLAVOR of type <i>int</i>
<i>WIN_MODEL</i>	Constant WIN_MODEL of type <i>int</i>
<i>SUCCESS</i>	Constant SUCCESS of type <i>int</i>
<i>ERR_LASTCODE</i>	Constant ERR_LASTCODE of type <i>int</i>
<i>ERR_COMM</i>	Constant ERR_COMM of type <i>int</i>
<i>ERR_GROUP</i>	Constant ERR_GROUP of type <i>int</i>
<i>ERR_TYPE</i>	Constant ERR_TYPE of type <i>int</i>
<i>ERR_REQUEST</i>	Constant ERR_REQUEST of type <i>int</i>

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Table 1 – continued from previous page

ERR_OP	Constant ERR_OP of type <code>int</code>
ERR_ERRHANDLER	Constant ERR_ERRHANDLER of type <code>int</code>
ERR_BUFFER	Constant ERR_BUFFER of type <code>int</code>
ERR_COUNT	Constant ERR_COUNT of type <code>int</code>
ERR_TAG	Constant ERR_TAG of type <code>int</code>
ERR_RANK	Constant ERR_RANK of type <code>int</code>
ERR_ROOT	Constant ERR_ROOT of type <code>int</code>
ERR_TRUNCATE	Constant ERR_TRUNCATE of type <code>int</code>
ERR_IN_STATUS	Constant ERR_IN_STATUS of type <code>int</code>
ERR_PENDING	Constant ERR_PENDING of type <code>int</code>
ERR_TOPOLOGY	Constant ERR_TOPOLOGY of type <code>int</code>
ERR_DIMS	Constant ERR_DIMS of type <code>int</code>
ERR_ARG	Constant ERR_ARG of type <code>int</code>
ERR_OTHER	Constant ERR_OTHER of type <code>int</code>
ERR_UNKNOWN	Constant ERR_UNKNOWN of type <code>int</code>
ERR_INTERN	Constant ERR_INTERN of type <code>int</code>
ERR_INFO	Constant ERR_INFO of type <code>int</code>
ERR_FILE	Constant ERR_FILE of type <code>int</code>
ERR_WIN	Constant ERR_WIN of type <code>int</code>
ERR_KEYVAL	Constant ERR_KEYVAL of type <code>int</code>
ERR_INFO_KEY	Constant ERR_INFO_KEY of type <code>int</code>
ERR_INFO_VALUE	Constant ERR_INFO_VALUE of type <code>int</code>
ERR_INFO_NOKEY	Constant ERR_INFO_NOKEY of type <code>int</code>
ERR_ACCESS	Constant ERR_ACCESS of type <code>int</code>
ERR_AMODE	Constant ERR_AMODE of type <code>int</code>
ERR_BAD_FILE	Constant ERR_BAD_FILE of type <code>int</code>
ERR_FILE_EXISTS	Constant ERR_FILE_EXISTS of type <code>int</code>
ERR_FILE_IN_USE	Constant ERR_FILE_IN_USE of type <code>int</code>
ERR_NO_SPACE	Constant ERR_NO_SPACE of type <code>int</code>
ERR_NO_SUCH_FILE	Constant ERR_NO_SUCH_FILE of type <code>int</code>
ERR_IO	Constant ERR_IO of type <code>int</code>
ERR_READ_ONLY	Constant ERR_READ_ONLY of type <code>int</code>
ERR_CONVERSION	Constant ERR_CONVERSION of type <code>int</code>
ERR_DUP_DATAREP	Constant ERR_DUP_DATAREP of type <code>int</code>
ERR_UNSUPPORTED_DATAREP	Constant ERR_UNSUPPORTED_DATAREP of type <code>int</code>
ERR_UNSUPPORTED_OPERATION	Constant ERR_UNSUPPORTED_OPERATION of type <code>int</code>
ERR_NAME	Constant ERR_NAME of type <code>int</code>
ERR_NO_MEM	Constant ERR_NO_MEM of type <code>int</code>
ERR_NOT_SAME	Constant ERR_NOT_SAME of type <code>int</code>
ERR_PORT	Constant ERR_PORT of type <code>int</code>
ERR_QUOTA	Constant ERR_QUOTA of type <code>int</code>
ERR_SERVICE	Constant ERR_SERVICE of type <code>int</code>
ERR_SPAWN	Constant ERR_SPAWN of type <code>int</code>
ERR_BASE	Constant ERR_BASE of type <code>int</code>
ERR_SIZE	Constant ERR_SIZE of type <code>int</code>
ERR_DISP	Constant ERR_DISP of type <code>int</code>
ERR_ASSERT	Constant ERR_ASSERT of type <code>int</code>
ERR_LOCKTYPE	Constant ERR_LOCKTYPE of type <code>int</code>
ERR_RMA_CONFLICT	Constant ERR_RMA_CONFLICT of type <code>int</code>
ERR_RMA_SYNC	Constant ERR_RMA_SYNC of type <code>int</code>
ERR_RMA_RANGE	Constant ERR_RMA_RANGE of type <code>int</code>
ERR_RMA_ATTACH	Constant ERR_RMA_ATTACH of type <code>int</code>

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Table 1 – continued from previous page

ERR_RMA_SHARED	Constant ERR_RMA_SHARED of type <code>int</code>
ERR_RMA_FLAVOR	Constant ERR_RMA_FLAVOR of type <code>int</code>
ORDER_C	Constant ORDER_C of type <code>int</code>
ORDER_F	Constant ORDER_F of type <code>int</code>
ORDER_FORTRAN	Constant ORDER_FORTRAN of type <code>int</code>
TYPECLASS_INTEGER	Constant TYPECLASS_INTEGER of type <code>int</code>
TYPECLASS_REAL	Constant TYPECLASS_REAL of type <code>int</code>
TYPECLASS_COMPLEX	Constant TYPECLASS_COMPLEX of type <code>int</code>
DISTRIBUTE_NONE	Constant DISTRIBUTE_NONE of type <code>int</code>
DISTRIBUTE_BLOCK	Constant DISTRIBUTE_BLOCK of type <code>int</code>
DISTRIBUTE_CYCLIC	Constant DISTRIBUTE_CYCLIC of type <code>int</code>
DISTRIBUTE_DFLT_DARG	Constant DISTRIBUTE_DFLT_DARG of type <code>int</code>
COMBINER_NAMED	Constant COMBINER_NAMED of type <code>int</code>
COMBINER_DUP	Constant COMBINER_DUP of type <code>int</code>
COMBINER_CONTIGUOUS	Constant COMBINER_CONTIGUOUS of type <code>int</code>
COMBINER_VECTOR	Constant COMBINER_VECTOR of type <code>int</code>
COMBINER_HVECTOR	Constant COMBINER_HVECTOR of type <code>int</code>
COMBINER_INDEXED	Constant COMBINER_INDEXED of type <code>int</code>
COMBINER_HINDEXED	Constant COMBINER_HINDEXED of type <code>int</code>
COMBINER_INDEXED_BLOCK	Constant COMBINER_INDEXED_BLOCK of type <code>int</code>
COMBINER_HINDEXED_BLOCK	Constant COMBINER_HINDEXED_BLOCK of type <code>int</code>
COMBINER_STRUCT	Constant COMBINER_STRUCT of type <code>int</code>
COMBINER_SUBARRAY	Constant COMBINER_SUBARRAY of type <code>int</code>
COMBINER_DARRAY	Constant COMBINER_DARRAY of type <code>int</code>
COMBINER_RESIZED	Constant COMBINER_RESIZED of type <code>int</code>
COMBINER_VALUE_INDEX	Constant COMBINER_VALUE_INDEX of type <code>int</code>
COMBINER_F90_REAL	Constant COMBINER_F90_REAL of type <code>int</code>
COMBINER_F90_COMPLEX	Constant COMBINER_F90_COMPLEX of type <code>int</code>
COMBINER_F90_INTEGER	Constant COMBINER_F90_INTEGER of type <code>int</code>
IDENT	Constant IDENT of type <code>int</code>
CONGRUENT	Constant CONGRUENT of type <code>int</code>
SIMILAR	Constant SIMILAR of type <code>int</code>
UNEQUAL	Constant UNEQUAL of type <code>int</code>
CART	Constant CART of type <code>int</code>
GRAPH	Constant GRAPH of type <code>int</code>
DIST_GRAPH	Constant DIST_GRAPH of type <code>int</code>
UNWEIGHTED	Constant UNWEIGHTED of type <code>int</code>
WEIGHTS_EMPTY	Constant WEIGHTS_EMPTY of type <code>int</code>
COMM_TYPE_SHARED	Constant COMM_TYPE_SHARED of type <code>int</code>
BSEND_OVERHEAD	Constant BSEND_OVERHEAD of type <code>int</code>
WIN_FLAVOR_CREATE	Constant WIN_FLAVOR_CREATE of type <code>int</code>
WIN_FLAVOR_ALLOCATE	Constant WIN_FLAVOR_ALLOCATE of type <code>int</code>
WIN_FLAVOR_DYNAMIC	Constant WIN_FLAVOR_DYNAMIC of type <code>int</code>
WIN_FLAVOR_SHARED	Constant WIN_FLAVOR_SHARED of type <code>int</code>
WIN_SEPARATE	Constant WIN_SEPARATE of type <code>int</code>
WIN_UNIFIED	Constant WIN_UNIFIED of type <code>int</code>
MODE_NOCHECK	Constant MODE_NOCHECK of type <code>int</code>
MODE_NOSTORE	Constant MODE_NOSTORE of type <code>int</code>
MODE_NOPUT	Constant MODE_NOPUT of type <code>int</code>
MODE_NOPRECEDE	Constant MODE_NOPRECEDE of type <code>int</code>
MODE_NOSUCCEED	Constant MODE_NOSUCCEED of type <code>int</code>
LOCK_EXCLUSIVE	Constant LOCK_EXCLUSIVE of type <code>int</code>

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Table 1 – continued from previous page

LOCK_SHARED	Constant LOCK_SHARED of type <i>int</i>
MODE_RDONLY	Constant MODE_RDONLY of type <i>int</i>
MODE_WRONLY	Constant MODE_WRONLY of type <i>int</i>
MODE_RDWR	Constant MODE_RDWR of type <i>int</i>
MODE_CREATE	Constant MODE_CREATE of type <i>int</i>
MODE_EXCL	Constant MODE_EXCL of type <i>int</i>
MODE_DELETE_ON_CLOSE	Constant MODE_DELETE_ON_CLOSE of type <i>int</i>
MODE_UNIQUE_OPEN	Constant MODE_UNIQUE_OPEN of type <i>int</i>
MODE_SEQUENTIAL	Constant MODE_SEQUENTIAL of type <i>int</i>
MODE_APPEND	Constant MODE_APPEND of type <i>int</i>
SEEK_SET	Constant SEEK_SET of type <i>int</i>
SEEK_CUR	Constant SEEK_CUR of type <i>int</i>
SEEK_END	Constant SEEK_END of type <i>int</i>
DISPLACEMENT_CURRENT	Constant DISPLACEMENT_CURRENT of type <i>int</i>
DISP_CUR	Constant DISP_CUR of type <i>int</i>
THREAD_SINGLE	Constant THREAD_SINGLE of type <i>int</i>
THREAD_FUNNELED	Constant THREAD_FUNNELED of type <i>int</i>
THREAD_SERIALIZED	Constant THREAD_SERIALIZED of type <i>int</i>
THREAD_MULTIPLE	Constant THREAD_MULTIPLE of type <i>int</i>
VERSION	Constant VERSION of type <i>int</i>
SUBVERSION	Constant SUBVERSION of type <i>int</i>
MAX_PROCESSOR_NAME	Constant MAX_PROCESSOR_NAME of type <i>int</i>
MAX_ERROR_STRING	Constant MAX_ERROR_STRING of type <i>int</i>
MAX_PORT_NAME	Constant MAX_PORT_NAME of type <i>int</i>
MAX_INFO_KEY	Constant MAX_INFO_KEY of type <i>int</i>
MAX_INFO_VAL	Constant MAX_INFO_VAL of type <i>int</i>
MAX_OBJECT_NAME	Constant MAX_OBJECT_NAME of type <i>int</i>
MAX_DATAREP_STRING	Constant MAX_DATAREP_STRING of type <i>int</i>
MAX_LIBRARY_VERSION_STRING	Constant MAX_LIBRARY_VERSION_STRING of type <i>int</i>
DATATYPE_NULL	Object DATATYPE_NULL of type <i>Datatype</i>
PACKED	Object PACKED of type <i>Datatype</i>
BYTE	Object BYTE of type <i>Datatype</i>
AINT	Object AINT of type <i>Datatype</i>
OFFSET	Object OFFSET of type <i>Datatype</i>
COUNT	Object COUNT of type <i>Datatype</i>
CHAR	Object CHAR of type <i>Datatype</i>
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>

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Table 1 – continued from previous page

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>
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>
LOGICAL8	Object LOGICAL8 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>

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Table 1 – continued from previous page

<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>
<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

[dlpack:python-spec](#)

`mpi4py.typing.SupportsCAI` = <class 'mpi4py.typing.SupportsCAI'>  
CUDA Array Interface (CAI) protocol.

#### See also

`numba:cuda-array-interface`

`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 'numbers.Integral'>

Address-sized integral type.

alias of [`numbers.Integral`](#)

`mpi4py.typing.Count` = <class 'numbers.Integral'>

Integral type for counts.

alias of [`numbers.Integral`](#)

`mpi4py.typing.Displ` = <class 'numbers.Integral'>

Integral type for displacements.

alias of [`numbers.Integral`](#)

`mpi4py.typing.Offset` = <class 'numbers.Integral'>

Integral type for offsets.

alias of [`numbers.Integral`](#)

`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*, *Integral*] | *Tuple*[*SupportsBuffer* | *SupportsDLPack* | *SupportsCAI*, *Datatype* | *str*] | *Tuple*[*SupportsBuffer* | *SupportsDLPack* | *SupportsCAI*, *Integral*, *Datatype* | *str*] | *Tuple*[*BottomType* | *None*, *Integral*, *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*, *Integral*] | *Tuple*[*SupportsBuffer* | *SupportsDLPack* | *SupportsCAI*, *Datatype* | *str*] | *Tuple*[*SupportsBuffer* | *SupportsDLPack* | *SupportsCAI*, *Integral*, *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*[*Integral*]] | *Tuple*[*SupportsBuffer* | *SupportsDLPack* | *SupportsCAI*, *Tuple*[*Sequence*[*Integral*], *Sequence*[*Integral*]]] | *Tuple*[*SupportsBuffer* | *SupportsDLPack* | *SupportsCAI*, *Datatype* | *str*] | *Tuple*[*SupportsBuffer* | *SupportsDLPack* | *SupportsCAI*, *Sequence*[*Integral*], *Datatype* | *str*] | *Tuple*[*SupportsBuffer* | *SupportsDLPack* | *SupportsCAI*, *Tuple*[*Sequence*[*Integral*], *Sequence*[*Integral*]], *Datatype* | *str*] | *Tuple*[*SupportsBuffer* | *SupportsDLPack* | *SupportsCAI*, *Sequence*[*Integral*], *Sequence*[*Integral*], *Datatype* | *str*] | *Tuple*[*BottomType* | *None*, *Tuple*[*Sequence*[*Integral*], *Sequence*[*Integral*]], *Datatype*] | *Tuple*[*BottomType* | *None*, *Sequence*[*Integral*], *Sequence*[*Integral*], *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[Integral], Sequence[Integral]], Sequence[Datatype]] | Tuple[SupportsBuffer | SupportsDLPack | SupportsCAI, Sequence[Integral], Sequence[Integral], Sequence[Datatype]] | Tuple[BottomType | None, Tuple[Sequence[Integral], Sequence[Integral]], Sequence[Datatype]] | Tuple[BottomType | None, Sequence[Integral], Sequence[Integral], Sequence[Datatype]] | List[Any]`

`mpi4py.typing.TargetSpec`

Target specification.

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

alias of `Integral | Tuple | Tuple[Integral] | Tuple[Integral, Integral] | Tuple[Integral, Integral, 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.

### 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\_pickle5*: If set to `True`, use `pickle5` with out-of-band buffers for interprocess communication. If *use\_pickle5* is set to `None` or not given, its value is determined from the `MPI4PY_FUTURES_USE_PICKLE5` environment variable. Using `pickle5` with out-of-band buffers may benefit applications dealing with large buffer-like objects like NumPy arrays. See `mpi4py.util.pickle5` 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**(*func*, \**args*, \*\**kwargs*)

Schedule the callable, *func*, to be executed as `func(*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**(*func*, \**iterables*, *timeout=None*, *chunksize=1*, \*\**kwargs*)

Equivalent to `map(func, *iterables)` except *func* is executed asynchronously and several calls to *func* 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 a call 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)
```

**starmap**(*func*, *iterable*, *timeout=None*, *chunksize=1*, \*\**kwargs*)

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

```

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

```

**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()

```

**bootstrap**(*wait=True*)

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

**num\_workers**

Number of 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 `pickle5` 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 `pickle5` 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)
```

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```

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
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:

```

(continues on next page)



```

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 implementations<sup>1</sup>. 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`:

```
$ 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  $\pi$  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*.

<sup>1</sup> 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.



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
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.dtlb.from_numpy_dtype(dtype)`

Convert NumPy datatype to MPI datatype.

**Parameters**

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

**Return type**

*Datatype*

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

Convert MPI datatype to NumPy datatype.

**Parameters**

**datatype** (*Datatype*) – MPI datatype.

**Return type**

*dtype*[*Any*]

## 8.2 mpi4py.util.pkl5

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.pkl5` 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).

### Note

Support for pickle protocol 5 is available in the `pickle` module within the Python standard library since Python 3.8. Previous Python 3 releases can use the `pickle5` backport, which is available on [PyPI](#) and can be installed with:

```
python -m pip install pickle5
```

**class** `mpi4py.util.pkl5.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.pkl5.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.pkl5.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
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`.

### 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*[*[...]*, *None*] | *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*

### 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]`) – 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 translated 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.
<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: `int`

Type of *BOTTOM*.

**static** `__new__(cls)`

**Return type**

*Self*

### mpi4py.MPI.BufferAutomaticType

**class** mpi4py.MPI.BufferAutomaticType

Bases: `int`

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.

## 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.
<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.

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<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.
<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.

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<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.
<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>gather</i> (sendobj[, root])	Gather.
<i>ibsend</i> (obj, dest[, tag])	Nonblocking send in buffered mode.

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<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.

## 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.
<i>topology</i>	Topology type.

## 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*, *recvcounts*=*None*, *op*=*SUM*)

Nonblocking Reduce-Scatter (vector version).

**Parameters**

- **sendbuf** (*BufSpec* / *InPlace*)
- **recvbuf** (*BufSpec*)
- **recvcounts** (*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(f $d$ )`

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*

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

Gather.

**Parameters**

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

**Return type**

*list[Any]* | *None*

**isend**(*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*

## 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.

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<i>Create_resized</i> (lb, extent)	Create a datatype with a new lower bound and extent.
<i>Create_struct</i> (blocklengths, displacements, ...)	Create a general composite (struct) datatype.
<i>Create_subarray</i> (sizes, subsizes, starts[, order])	Create a datatype for a subarray of a multidimensional array.
<i>Create_vector</i> (count, blocklength, stride)	Create a vector (strided) datatype.
<i>Delete_attr</i> (keyval)	Delete attribute value associated with a key.
<i>Dup</i> ()	Duplicate a datatype.
<i>Free</i> ()	Free the datatype.
<i>Free_keyval</i> (keyval)	Free an attribute key for datatypes.
<i>Get_attr</i> (keyval)	Retrieve attribute value by key.
<i>Get_contents</i> ()	Return the input arguments used to create a datatype.
<i>Get_envelope</i> ()	Return the number of input arguments used to create a datatype.
<i>Get_extent</i> ()	Return lower bound and extent of datatype.
<i>Get_name</i> ()	Get the print name for this datatype.
<i>Get_size</i> ()	Return the number of bytes occupied by entries in the datatype.
<i>Get_true_extent</i> ()	Return the true lower bound and extent of a datatype.
<i>Get_value_index</i> (value, index)	Return a predefined pair datatype.
<i>Match_size</i> (typeclass, size)	Find a datatype matching a specified size in bytes.
<i>Pack</i> (inbuf, outbuf, position, comm)	Pack into contiguous memory according to datatype.
<i>Pack_external</i> (datarep, inbuf, outbuf, position)	Pack into contiguous memory according to datatype.
<i>Pack_external_size</i> (datarep, count)	Determine the amount of space needed to pack a message.
<i>Pack_size</i> (count, comm)	Determine the amount of space needed to pack a message.
<i>Set_attr</i> (keyval, attrval)	Store attribute value associated with a key.
<i>Set_name</i> (name)	Set the print name for this datatype.
<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>py2f</i> ()	
<i>toencode</i> ()	Get character code or type string from predefined MPI datatype.

## 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

**py2f()**

**Return type**  
int

**tocode()**

Get character code or type string from predefined MPI datatype.

**Return type**  
str

## 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**

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

<i>Free()</i>	Free an error handler.
<i>f2py(arg)</i>	
<i>free()</i>	Call <i>Free</i> if not null.
<i>fromhandle(handle)</i>	Create object from MPI handle.
<i>py2f()</i>	

## Attributes Summary

<i>handle</i>	MPI handle.
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## 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*

### **py2f()**

**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_atomicsity</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.

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<i>Read</i> (buf[, status])	Read using individual file pointer.
<i>Read_all</i> (buf[, status])	Collective read using individual file pointer.
<i>Read_all_begin</i> (buf)	Start a split collective read using individual file pointer.
<i>Read_all_end</i> (buf[, status])	Complete a split collective read using individual file pointer.
<i>Read_at</i> (offset, buf[, status])	Read using explicit offset.
<i>Read_at_all</i> (offset, buf[, status])	Collective read using explicit offset.
<i>Read_at_all_begin</i> (offset, buf)	Start a split collective read using explicit offset.
<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_atomics</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>py2f</i> ()	



## Attributes Summary

<code>amode</code>	Access mode.
<code>atomicity</code>	Atomicity mode.
<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>size</code>	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*

**py2f()**

**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

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

## Attributes Summary

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

<i>Compare</i> (group)	Compare two groups.
<i>Create_from_session_pset</i> (session, pset_name)	Create a new group from session and process set.
<i>Difference</i> (group1, group2)	Create a new group from the difference of two existing groups.
<i>Dup</i> ()	Duplicate a group.
<i>Excl</i> (ranks)	Create a new group by excluding listed members.
<i>Free</i> ()	Free a group.
<i>Get_rank</i> ()	Return the rank of this process in a group.
<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>py2f</i> ()	

## 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*

**py2f**()

**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: *int*

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

<i>Create</i> ([items])	Create a new info object.
<i>Create_env</i> ([args])	Create a new environment info object.
<i>Delete</i> (key)	Remove a (key, value) pair from info.
<i>Dup</i> ()	Duplicate an existing info object.
<i>Free</i> ()	Free an info object.
<i>Get</i> (key)	Retrieve the value associated with a key.
<i>Get_nkeys</i> ()	Return the number of currently defined keys in info.
<i>Get_nthkey</i> (n)	Return the <i>n</i> -th defined key in info.
<i>Set</i> (key, value)	Store a value associated with a key.
<i>clear</i> ()	Clear contents.
<i>copy</i> ()	Copy contents.
<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>get</i> (key[, default])	Retrieve value by key.
<i>items</i> ()	Return list of items.
<i>keys</i> ()	Return list of keys.
<i>pop</i> (key, *default)	Pop value by key.
<i>popitem</i> ()	Pop first item.
<i>py2f</i> ()	
<i>update</i> ([items])	Update contents.
<i>values</i> ()	Return list of values.

## Attributes Summary

<i>handle</i>	MPI handle.
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## 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*

**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`

**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</code> ( <code>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</code> ( <code>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** (str)
- **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[str]*)
- **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>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.

## 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 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*

## 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(function[, commute])</code>	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(inbuf, inoutbuf)</code>	Apply a reduction operation to local data.
<code>f2py(arg)</code>	
<code>free()</code>	Call <code>Free</code> if not null or predefined.
<code>fromhandle(handle)</code>	Create object from MPI handle.
<code>py2f()</code>	

## 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`

**py2f()**

**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

<i>dumps</i> (obj)	Serialize object to pickle data stream.
<i>dumps_oob</i> (obj)	Serialize object to pickle data stream and out-of-band buffers.
<i>loads</i> (data)	Deserialize object from pickle data stream.
<i>loads_oob</i> (data, buffers)	Deserialize object from pickle data stream and out-of-band buffers.

## Attributes Summary

<i>PROTOCOL</i>	Protocol version.
<i>THRESHOLD</i>	Out-of-band threshold.

## Methods Documentation

### **dumps**(obj)

Serialize object to pickle data stream.

#### **Parameters**

**obj** (*Any*)

#### **Return type**

bytes

### **dumps\_oob**(obj)

Serialize object to pickle data stream and out-of-band buffers.

#### **Parameters**

**obj** (*Any*)

#### **Return type**

tuple[bytes, list[buffer]]

### **loads**(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.Prerequest

**class** mpi4py.MPI.Prerequest

Bases: *Request*

Persistent request handler.

**static** *\_\_new\_\_*(cls, request=None)

#### Parameters

**request** (*Prerequest* | *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>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>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

<i>handle</i>	MPI handle.
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## 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** **Waitsome**(*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

**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*]

**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** `waitsome(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**

<i>Attach_buffer</i> (buf)	Attach a user-provided buffer for sending in buffered mode.
<i>Call_errhandler</i> (errorcode)	Call the error handler installed on a session.
<i>Create_errhandler</i> (errhandler_fn)	Create a new error handler for sessions.
<i>Create_group</i> (pset_name)	Create a new group from session and process set.
<i>Detach_buffer</i> ()	Remove an existing attached buffer.
<i>Finalize</i> ()	Finalize a session.
<i>Flush_buffer</i> ()	Block until all buffered messages have been transmitted.
<i>Get_errhandler</i> ()	Get the error handler for a session.
<i>Get_info</i> ()	Return the current hints for a session.
<i>Get_nth_pset</i> (n[, info])	Name of the <i>n</i> -th process set.
<i>Get_num_psets</i> ([info])	Number of available process sets.
<i>Get_pset_info</i> (pset_name)	Return the current hints for a session and process set.
<i>Iflush_buffer</i> ()	Nonblocking flush for buffered messages.
<i>Init</i> ([info, errhandler])	Create a new session.
<i>Set_errhandler</i> (errhandler)	Set the error handler for a session.
<i>f2py</i> (arg)	
<i>free</i> ()	Call <i>Finalize</i> if not null.
<i>fromhandle</i> (handle)	Create object from MPI handle.
<i>py2f</i> ()	

## Attributes Summary

<i>handle</i>	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](#)

**py2f**()

**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>	

## 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]*

## 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>inneighbor_allgather</i> (sendbuf, recvbuf)	Nonblocking Neighbor Gather to All.
<i>inneighbor_allgatherv</i> (sendbuf, recvbuf)	Nonblocking Neighbor Gather to All Vector.
<i>inneighbor_alltoall</i> (sendbuf, recvbuf)	Nonblocking Neighbor All to All.
<i>inneighbor_alltoallv</i> (sendbuf, recvbuf)	Nonblocking Neighbor All to All Vector.
<i>inneighbor_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.
<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

<i>Accumulate</i> (origin, target_rank[, target, op])	Accumulate data into the target process.
<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.

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<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.
<i>Test</i> ()	Test whether an RMA exposure epoch has completed.
<i>Unlock</i> (rank)	Complete an RMA access epoch at the target process.
<i>Unlock_all</i> ()	Complete an RMA access epoch at all processes.
<i>Wait</i> ()	Complete an RMA exposure epoch begun with <i>Post</i> .
<i>f2py</i> (arg)	
<i>free</i> ()	Call <i>Free</i> if not null.
<i>fromhandle</i> (handle)	Create object from MPI handle.
<i>py2f</i> ()	
<i>tomemory</i> ()	Return window memory buffer.

## Attributes Summary

<i>attrs</i>	Attributes.
<i>flavor</i>	Create flavor.
<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>model</i>	Memory model.
<i>name</i>	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*

**py2f()**

**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.
<code>release</code> ()	Release the underlying buffer exposed by the buffer object.
<code>tobytes</code> ([order])	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

<i>Exception</i>	Exception class.
------------------	------------------

### mpi4py.MPI.Exception

**exception** mpi4py.MPI.Exception

Bases: `RuntimeError`

Exception class.

**static** `__new__(cls, ierr=SUCCESS)`

**Parameters**

**ierr** (`int`)

**Return type**

*Self*

### 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

<a href="#"><i>Add_error_class()</i></a>	Add an <i>error class</i> to the known error classes.
<a href="#"><i>Add_error_code</i>(errorclass)</a>	Add an <i>error code</i> to an <i>error class</i> .
<a href="#"><i>Add_error_string</i>(errorcode, string)</a>	Associate an <i>error string</i> with an <i>error class</i> or <i>error code</i> .
<a href="#"><i>Aint_add</i>(base, disp)</a>	Return the sum of base address and displacement.
<a href="#"><i>Aint_diff</i>(addr1, addr2)</a>	Return the difference between absolute addresses.
<a href="#"><i>Alloc_mem</i>(size[, info])</a>	Allocate memory for message passing and remote memory access.
<a href="#"><i>Attach_buffer</i>(buf)</a>	Attach a user-provided buffer for sending in buffered mode.
<a href="#"><i>Close_port</i>(port_name)</a>	Close a port.
<a href="#"><i>Compute_dims</i>(nnodes, dims)</a>	Return a balanced distribution of processes per coordinate direction.
<a href="#"><i>Detach_buffer</i>()</a>	Remove an existing attached buffer.
<a href="#"><i>Finalize</i>()</a>	Terminate the MPI execution environment.
<a href="#"><i>Flush_buffer</i>()</a>	Block until all buffered messages have been transmitted.
<a href="#"><i>Free_mem</i>(mem)</a>	Free memory allocated with <a href="#"><i>Alloc_mem</i></a> .
<a href="#"><i>Get_address</i>(location)</a>	Get the address of a location in memory.
<a href="#"><i>Get_error_class</i>(errorcode)</a>	Convert an <i>error code</i> into an <i>error class</i> .
<a href="#"><i>Get_error_string</i>(errorcode)</a>	Return the <i>error string</i> for a given <i>error class</i> or <i>error code</i> .
<a href="#"><i>Get_hw_resource_info</i>()</a>	Obtain information about the hardware platform of the calling processor.
<a href="#"><i>Get_library_version</i>()</a>	Obtain the version string of the MPI library.
<a href="#"><i>Get_processor_name</i>()</a>	Obtain the name of the calling processor.
<a href="#"><i>Get_version</i>()</a>	Obtain the version number of the MPI standard.
<a href="#"><i>Iflush_buffer</i>()</a>	Nonblocking flush for buffered messages.
<a href="#"><i>Init</i>()</a>	Initialize the MPI execution environment.
<a href="#"><i>Init_thread</i>([required])</a>	Initialize the MPI execution environment.
<a href="#"><i>Is_finalized</i>()</a>	Indicate whether <a href="#"><i>Finalize</i></a> has completed.
<a href="#"><i>Is_initialized</i>()</a>	Indicate whether <a href="#"><i>Init</i></a> has been called.
<a href="#"><i>Is_thread_main</i>()</a>	Indicate whether this thread called <a href="#"><i>Init</i></a> or <a href="#"><i>Init_thread</i></a> .
<a href="#"><i>Lookup_name</i>(service_name[, info])</a>	Lookup a port name given a service name.
<a href="#"><i>Open_port</i>([info])</a>	Return an address used to connect group of processes.
<a href="#"><i>Pcontrol</i>(level)</a>	Control profiling.
<a href="#"><i>Publish_name</i>(service_name, port_name[, info])</a>	Publish a service name.
<a href="#"><i>Query_thread</i>()</a>	Return the level of thread support provided by the MPI library.

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

**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\_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 <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>
<i>ROOT</i>	Constant ROOT of type <i>int</i>
<i>BOTTOM</i>	Constant BOTTOM of type <i>BottomType</i>
<i>IN_PLACE</i>	Constant IN_PLACE of type <i>InPlaceType</i>
<i>KEYVAL_INVALID</i>	Constant KEYVAL_INVALID of type <i>int</i>
<i>TAG_UB</i>	Constant TAG_UB of type <i>int</i>
<i>IO</i>	Constant IO of type <i>int</i>
<i>WTIME_IS_GLOBAL</i>	Constant WTIME_IS_GLOBAL of type <i>int</i>
<i>UNIVERSE_SIZE</i>	Constant UNIVERSE_SIZE of type <i>int</i>
<i>APPNUM</i>	Constant APPNUM of type <i>int</i>
<i>LASTUSEDPCODE</i>	Constant LASTUSEDPCODE of type <i>int</i>
<i>WIN_BASE</i>	Constant WIN_BASE of type <i>int</i>
<i>WIN_SIZE</i>	Constant WIN_SIZE of type <i>int</i>
<i>WIN_DISP_UNIT</i>	Constant WIN_DISP_UNIT of type <i>int</i>
<i>WIN_CREATE_FLAVOR</i>	Constant WIN_CREATE_FLAVOR of type <i>int</i>
<i>WIN_FLAVOR</i>	Constant WIN_FLAVOR of type <i>int</i>
<i>WIN_MODEL</i>	Constant WIN_MODEL of type <i>int</i>

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Table 8 – continued from previous page

<code>SUCCESS</code>	Constant <code>SUCCESS</code> of type <code>int</code>
<code>ERR_LASTCODE</code>	Constant <code>ERR_LASTCODE</code> of type <code>int</code>
<code>ERR_TYPE</code>	Constant <code>ERR_TYPE</code> of type <code>int</code>
<code>ERR_REQUEST</code>	Constant <code>ERR_REQUEST</code> of type <code>int</code>
<code>ERR_OP</code>	Constant <code>ERR_OP</code> of type <code>int</code>
<code>ERR_GROUP</code>	Constant <code>ERR_GROUP</code> of type <code>int</code>
<code>ERR_INFO</code>	Constant <code>ERR_INFO</code> of type <code>int</code>
<code>ERR_ERRHANDLER</code>	Constant <code>ERR_ERRHANDLER</code> of type <code>int</code>
<code>ERR_SESSION</code>	Constant <code>ERR_SESSION</code> of type <code>int</code>
<code>ERR_COMM</code>	Constant <code>ERR_COMM</code> of type <code>int</code>
<code>ERR_WIN</code>	Constant <code>ERR_WIN</code> of type <code>int</code>
<code>ERR_FILE</code>	Constant <code>ERR_FILE</code> of type <code>int</code>
<code>ERR_BUFFER</code>	Constant <code>ERR_BUFFER</code> of type <code>int</code>
<code>ERR_COUNT</code>	Constant <code>ERR_COUNT</code> of type <code>int</code>
<code>ERR_TAG</code>	Constant <code>ERR_TAG</code> of type <code>int</code>
<code>ERR_RANK</code>	Constant <code>ERR_RANK</code> of type <code>int</code>
<code>ERR_ROOT</code>	Constant <code>ERR_ROOT</code> of type <code>int</code>
<code>ERR_TRUNCATE</code>	Constant <code>ERR_TRUNCATE</code> of type <code>int</code>
<code>ERR_IN_STATUS</code>	Constant <code>ERR_IN_STATUS</code> of type <code>int</code>
<code>ERR_PENDING</code>	Constant <code>ERR_PENDING</code> of type <code>int</code>
<code>ERR_TOPOLOGY</code>	Constant <code>ERR_TOPOLOGY</code> of type <code>int</code>
<code>ERR_DIMS</code>	Constant <code>ERR_DIMS</code> of type <code>int</code>
<code>ERR_ARG</code>	Constant <code>ERR_ARG</code> of type <code>int</code>
<code>ERR_OTHER</code>	Constant <code>ERR_OTHER</code> of type <code>int</code>
<code>ERR_UNKNOWN</code>	Constant <code>ERR_UNKNOWN</code> of type <code>int</code>
<code>ERR_INTERN</code>	Constant <code>ERR_INTERN</code> of type <code>int</code>
<code>ERR_KEYVAL</code>	Constant <code>ERR_KEYVAL</code> of type <code>int</code>
<code>ERR_NO_MEM</code>	Constant <code>ERR_NO_MEM</code> of type <code>int</code>
<code>ERR_INFO_KEY</code>	Constant <code>ERR_INFO_KEY</code> of type <code>int</code>
<code>ERR_INFO_VALUE</code>	Constant <code>ERR_INFO_VALUE</code> of type <code>int</code>
<code>ERR_INFO_NOKEY</code>	Constant <code>ERR_INFO_NOKEY</code> of type <code>int</code>
<code>ERR_SPAWN</code>	Constant <code>ERR_SPAWN</code> of type <code>int</code>
<code>ERR_PORT</code>	Constant <code>ERR_PORT</code> of type <code>int</code>
<code>ERR_SERVICE</code>	Constant <code>ERR_SERVICE</code> of type <code>int</code>
<code>ERR_NAME</code>	Constant <code>ERR_NAME</code> of type <code>int</code>
<code>ERR_PROC_ABORTED</code>	Constant <code>ERR_PROC_ABORTED</code> of type <code>int</code>
<code>ERR_BASE</code>	Constant <code>ERR_BASE</code> of type <code>int</code>
<code>ERR_SIZE</code>	Constant <code>ERR_SIZE</code> of type <code>int</code>
<code>ERR_DISP</code>	Constant <code>ERR_DISP</code> of type <code>int</code>
<code>ERR_ASSERT</code>	Constant <code>ERR_ASSERT</code> of type <code>int</code>
<code>ERR_LOCKTYPE</code>	Constant <code>ERR_LOCKTYPE</code> of type <code>int</code>
<code>ERR_RMA_CONFLICT</code>	Constant <code>ERR_RMA_CONFLICT</code> of type <code>int</code>
<code>ERR_RMA_SYNC</code>	Constant <code>ERR_RMA_SYNC</code> of type <code>int</code>
<code>ERR_RMA_RANGE</code>	Constant <code>ERR_RMA_RANGE</code> of type <code>int</code>
<code>ERR_RMA_ATTACH</code>	Constant <code>ERR_RMA_ATTACH</code> of type <code>int</code>
<code>ERR_RMA_SHARED</code>	Constant <code>ERR_RMA_SHARED</code> of type <code>int</code>
<code>ERR_RMA_FLAVOR</code>	Constant <code>ERR_RMA_FLAVOR</code> of type <code>int</code>
<code>ERR_BAD_FILE</code>	Constant <code>ERR_BAD_FILE</code> of type <code>int</code>
<code>ERR_NO_SUCH_FILE</code>	Constant <code>ERR_NO_SUCH_FILE</code> of type <code>int</code>
<code>ERR_FILE_EXISTS</code>	Constant <code>ERR_FILE_EXISTS</code> of type <code>int</code>
<code>ERR_FILE_IN_USE</code>	Constant <code>ERR_FILE_IN_USE</code> of type <code>int</code>
<code>ERR_AMODE</code>	Constant <code>ERR_AMODE</code> of type <code>int</code>

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Table 8 – continued from previous page

ERR_ACCESS	Constant ERR_ACCESS of type <code>int</code>
ERR_READ_ONLY	Constant ERR_READ_ONLY of type <code>int</code>
ERR_NO_SPACE	Constant ERR_NO_SPACE of type <code>int</code>
ERR_QUOTA	Constant ERR_QUOTA of type <code>int</code>
ERR_NOT_SAME	Constant ERR_NOT_SAME of type <code>int</code>
ERR_IO	Constant ERR_IO of type <code>int</code>
ERR_UNSUPPORTED_OPERATION	Constant ERR_UNSUPPORTED_OPERATION of type <code>int</code>
ERR_UNSUPPORTED_DATAREP	Constant ERR_UNSUPPORTED_DATAREP of type <code>int</code>
ERR_CONVERSION	Constant ERR_CONVERSION of type <code>int</code>
ERR_DUP_DATAREP	Constant ERR_DUP_DATAREP of type <code>int</code>
ERR_VALUE_TOO_LARGE	Constant ERR_VALUE_TOO_LARGE of type <code>int</code>
ERR_REVOKED	Constant ERR_REVOKED of type <code>int</code>
ERR_PROC_FAILED	Constant ERR_PROC_FAILED of type <code>int</code>
ERR_PROC_FAILED_PENDING	Constant ERR_PROC_FAILED_PENDING of type <code>int</code>
ORDER_C	Constant ORDER_C of type <code>int</code>
ORDER_FORTTRAN	Constant ORDER_FORTTRAN of type <code>int</code>
ORDER_F	Constant ORDER_F of type <code>int</code>
TYPECLASS_INTEGER	Constant TYPECLASS_INTEGER of type <code>int</code>
TYPECLASS_REAL	Constant TYPECLASS_REAL of type <code>int</code>
TYPECLASS_COMPLEX	Constant TYPECLASS_COMPLEX of type <code>int</code>
DISTRIBUTE_NONE	Constant DISTRIBUTE_NONE of type <code>int</code>
DISTRIBUTE_BLOCK	Constant DISTRIBUTE_BLOCK of type <code>int</code>
DISTRIBUTE_CYCLIC	Constant DISTRIBUTE_CYCLIC of type <code>int</code>
DISTRIBUTE_DFLT_DARG	Constant DISTRIBUTE_DFLT_DARG of type <code>int</code>
COMBINER_NAMED	Constant COMBINER_NAMED of type <code>int</code>
COMBINER_DUP	Constant COMBINER_DUP of type <code>int</code>
COMBINER_CONTIGUOUS	Constant COMBINER_CONTIGUOUS of type <code>int</code>
COMBINER_VECTOR	Constant COMBINER_VECTOR of type <code>int</code>
COMBINER_HVECTOR	Constant COMBINER_HVECTOR of type <code>int</code>
COMBINER_INDEXED	Constant COMBINER_INDEXED of type <code>int</code>
COMBINER_HINDEXED	Constant COMBINER_HINDEXED of type <code>int</code>
COMBINER_INDEXED_BLOCK	Constant COMBINER_INDEXED_BLOCK of type <code>int</code>
COMBINER_HINDEXED_BLOCK	Constant COMBINER_HINDEXED_BLOCK of type <code>int</code>
COMBINER_STRUCT	Constant COMBINER_STRUCT of type <code>int</code>
COMBINER_SUBARRAY	Constant COMBINER_SUBARRAY of type <code>int</code>
COMBINER_DARRAY	Constant COMBINER_DARRAY of type <code>int</code>
COMBINER_RESIZED	Constant COMBINER_RESIZED of type <code>int</code>
COMBINER_VALUE_INDEX	Constant COMBINER_VALUE_INDEX of type <code>int</code>
COMBINER_F90_INTEGER	Constant COMBINER_F90_INTEGER of type <code>int</code>
COMBINER_F90_REAL	Constant COMBINER_F90_REAL of type <code>int</code>
COMBINER_F90_COMPLEX	Constant COMBINER_F90_COMPLEX of type <code>int</code>
F_SOURCE	Constant F_SOURCE of type <code>int</code>
F_TAG	Constant F_TAG of type <code>int</code>
F_ERROR	Constant F_ERROR of type <code>int</code>
F_STATUS_SIZE	Constant F_STATUS_SIZE of type <code>int</code>
IDENT	Constant IDENT of type <code>int</code>
CONGRUENT	Constant CONGRUENT of type <code>int</code>
SIMILAR	Constant SIMILAR of type <code>int</code>
UNEQUAL	Constant UNEQUAL of type <code>int</code>
CART	Constant CART of type <code>int</code>
GRAPH	Constant GRAPH of type <code>int</code>
DIST_GRAPH	Constant DIST_GRAPH of type <code>int</code>

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Table 8 – continued from previous page

UNWEIGHTED	Constant UNWEIGHTED of type <i>int</i>
WEIGHTS_EMPTY	Constant WEIGHTS_EMPTY of type <i>int</i>
COMM_TYPE_SHARED	Constant COMM_TYPE_SHARED of type <i>int</i>
COMM_TYPE_HW_GUIDED	Constant COMM_TYPE_HW_GUIDED of type <i>int</i>
COMM_TYPE_HW_UNGUIDED	Constant COMM_TYPE_HW_UNGUIDED of type <i>int</i>
COMM_TYPE_RESOURCE_GUIDED	Constant COMM_TYPE_RESOURCE_GUIDED of type <i>int</i>
BSEND_OVERHEAD	Constant BSEND_OVERHEAD of type <i>int</i>
BUFFER_AUTOMATIC	Constant BUFFER_AUTOMATIC of type <i>BufferAutomaticType</i>
WIN_FLAVOR_CREATE	Constant WIN_FLAVOR_CREATE of type <i>int</i>
WIN_FLAVOR_ALLOCATE	Constant WIN_FLAVOR_ALLOCATE of type <i>int</i>
WIN_FLAVOR_DYNAMIC	Constant WIN_FLAVOR_DYNAMIC of type <i>int</i>
WIN_FLAVOR_SHARED	Constant WIN_FLAVOR_SHARED of type <i>int</i>
WIN_SEPARATE	Constant WIN_SEPARATE of type <i>int</i>
WIN_UNIFIED	Constant WIN_UNIFIED of type <i>int</i>
MODE_NOCHECK	Constant MODE_NOCHECK of type <i>int</i>
MODE_NOSTORE	Constant MODE_NOSTORE of type <i>int</i>
MODE_NOPUT	Constant MODE_NOPUT of type <i>int</i>
MODE_NOPRECEDE	Constant MODE_NOPRECEDE of type <i>int</i>
MODE_NOSUCCEED	Constant MODE_NOSUCCEED of type <i>int</i>
LOCK_EXCLUSIVE	Constant LOCK_EXCLUSIVE of type <i>int</i>
LOCK_SHARED	Constant LOCK_SHARED of type <i>int</i>
MODE_RDONLY	Constant MODE_RDONLY of type <i>int</i>
MODE_WRONLY	Constant MODE_WRONLY of type <i>int</i>
MODE_RDWR	Constant MODE_RDWR of type <i>int</i>
MODE_CREATE	Constant MODE_CREATE of type <i>int</i>
MODE_EXCL	Constant MODE_EXCL of type <i>int</i>
MODE_DELETE_ON_CLOSE	Constant MODE_DELETE_ON_CLOSE of type <i>int</i>
MODE_UNIQUE_OPEN	Constant MODE_UNIQUE_OPEN of type <i>int</i>
MODE_SEQUENTIAL	Constant MODE_SEQUENTIAL of type <i>int</i>
MODE_APPEND	Constant MODE_APPEND of type <i>int</i>
SEEK_SET	Constant SEEK_SET of type <i>int</i>
SEEK_CUR	Constant SEEK_CUR of type <i>int</i>
SEEK_END	Constant SEEK_END of type <i>int</i>
DISPLACEMENT_CURRENT	Constant DISPLACEMENT_CURRENT of type <i>int</i>
DISP_CUR	Constant DISP_CUR of type <i>int</i>
THREAD_SINGLE	Constant THREAD_SINGLE of type <i>int</i>
THREAD_FUNNELED	Constant THREAD_FUNNELED of type <i>int</i>
THREAD_SERIALIZED	Constant THREAD_SERIALIZED of type <i>int</i>
THREAD_MULTIPLE	Constant THREAD_MULTIPLE of type <i>int</i>
VERSION	Constant VERSION of type <i>int</i>
SUBVERSION	Constant SUBVERSION of type <i>int</i>
MAX_PROCESSOR_NAME	Constant MAX_PROCESSOR_NAME of type <i>int</i>
MAX_ERROR_STRING	Constant MAX_ERROR_STRING of type <i>int</i>
MAX_PORT_NAME	Constant MAX_PORT_NAME of type <i>int</i>
MAX_INFO_KEY	Constant MAX_INFO_KEY of type <i>int</i>
MAX_INFO_VAL	Constant MAX_INFO_VAL of type <i>int</i>
MAX_OBJECT_NAME	Constant MAX_OBJECT_NAME of type <i>int</i>
MAX_DATAREP_STRING	Constant MAX_DATAREP_STRING of type <i>int</i>
MAX_LIBRARY_VERSION_STRING	Constant MAX_LIBRARY_VERSION_STRING of type <i>int</i>
MAX_PSET_NAME_LEN	Constant MAX_PSET_NAME_LEN of type <i>int</i>
MAX_STRINGTAG_LEN	Constant MAX_STRINGTAG_LEN of type <i>int</i>

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Table 8 – continued from previous page

DATATYPE_NULL	Object DATATYPE_NULL of type <i>Datatype</i>
PACKED	Object PACKED of type <i>Datatype</i>
BYTE	Object BYTE of type <i>Datatype</i>
AINT	Object AINT of type <i>Datatype</i>
OFFSET	Object OFFSET of type <i>Datatype</i>
COUNT	Object COUNT of type <i>Datatype</i>
CHAR	Object CHAR of type <i>Datatype</i>
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>
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>

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Table 8 – continued from previous page

LOGICAL1	Object LOGICAL1 of type <i>Datatype</i>
LOGICAL2	Object LOGICAL2 of type <i>Datatype</i>
LOGICAL4	Object LOGICAL4 of type <i>Datatype</i>
LOGICAL8	Object LOGICAL8 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>

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Table 8 – continued from previous page

<i>GROUP_NULL</i>	Object GROUP_NULL of type <i>Group</i>
<i>GROUP_EMPTY</i>	Object GROUP_EMPTY of type <i>Group</i>
<i>INFO_NULL</i>	Object INFO_NULL of type <i>Info</i>
<i>INFO_ENV</i>	Object INFO_ENV of type <i>Info</i>
<i>ERRHANDLER_NULL</i>	Object ERRHANDLER_NULL of type <i>Errhandler</i>
<i>ERRORS_RETURN</i>	Object ERRORS_RETURN of type <i>Errhandler</i>
<i>ERRORS_ABORT</i>	Object ERRORS_ABORT of type <i>Errhandler</i>
<i>ERRORS_ARE_FATAL</i>	Object ERRORS_ARE_FATAL of type <i>Errhandler</i>
<i>SESSION_NULL</i>	Object SESSION_NULL of type <i>Session</i>
<i>COMM_NULL</i>	Object COMM_NULL of type <i>Comm</i>
<i>COMM_SELF</i>	Object COMM_SELF of type <i>Intracomm</i>
<i>COMM_WORLD</i>	Object COMM_WORLD of type <i>Intracomm</i>
<i>WIN_NULL</i>	Object WIN_NULL of type <i>Win</i>
<i>FILE_NULL</i>	Object FILE_NULL of type <i>File</i>
<i>pickle</i>	Object pickle 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.BOTTOM**

`mpi4py.MPI.BOTTOM: BottomType = BOTTOM`  
Constant BOTTOM of type *BottomType*

### **mpi4py.MPI.IN\_PLACE**

`mpi4py.MPI.IN_PLACE: InPlaceType = IN_PLACE`  
Constant IN\_PLACE of type *InPlaceType*

### **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.LASTUSEDCODE**

`mpi4py.MPI.LASTUSEDCODE: int = LASTUSEDCODE`  
Constant LASTUSEDCODE 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\_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\_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.BUFFER\_AUTOMATIC**

`mpi4py.MPI.BUFFER_AUTOMATIC: BufferAutomaticType = BUFFER_AUTOMATIC`  
Constant BUFFER\_AUTOMATIC of type *BufferAutomaticType*

### **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.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.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.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 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.

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.

## 13.2 Using pip

You can install the latest mpi4py release from its source distribution at [PyPI](#) using pip:

```
$ python -m pip install 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 at PyPI) or Git source code repository (available at GitHub) requires a C compiler and a working MPI implementation with development headers and libraries.

### Warning

pip keeps previously built wheel files on its cache for future reuse. If you want to reinstall the mpi4py package using a different or updated MPI implementation, you have to either first remove the cached wheel file with:

```
$ python -m pip cache remove mpi4py
```

or ask pip to disable the cache:

```
$ python -m pip install --no-cache-dir mpi4py
```

## 13.3 Using conda

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 msmpi
```

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

Binary conda-forge packages are built with a 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](#).

## 13.4 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
```

Note that on Ubuntu/Debian systems, the `mpi4py` package uses Open MPI. To use MPICH, install the `libmpich-dev` and `python3-dev` packages (and any other required development tools). Afterwards, install `mpi4py` from sources using `pip`.

## 13.5 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`.

## 13.6 Windows

Windows users can install mpi4py from binary wheels hosted on the Python Package Index (PyPI) using `pip`:

```
$ python -m pip install mpi4py
```

The Windows wheels available on PyPI are specially crafted to work with either the [Intel MPI](#) or the [Microsoft MPI](#) runtime, therefore requiring a separate installation of any one of these packages.

Intel MPI is under active development and supports recent version 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 HPC Toolkit for Windows or via standalone online/offline installers.

# 14 Development

## 14.1 Prerequisites

You need to have the following software properly installed to develop *MPI for Python*:

- [Python](#) 3.6 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.

**--mpil=**

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

[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 Forum is currently discussing the standardization of a proposal for an Application Binary Interface (ABI) for MPI, see [[mpi-abi-paper](#)] and [[mpi-abi-issue](#)]. Such standardization will allow for any binary dependent on the MPI library to be used with multiple MPI backends. Once this proposal becomes part of the MPI standard, the mpi4py project will consider publishing on PyPI binary wheels capable of using any backend MPI implementation supporting the new MPI ABI specification. In the mean time, mpi4py is currently distributing experimental MPI and mpi4py binary wheels on <https://anaconda.org/mpi4py>.

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 4.0.1 [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.pk15`.
  - Update compatibility workarounds for legacy MPICH 3.0 release.

## 17.2 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.

## 17.3 Release 3.1.6 [2024-04-14]

### Warning

This is the last release supporting Python 2.

- Fix various build issues.

## 17.4 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.

## 17.5 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.

## 17.6 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.

## 17.7 Release 3.1.2 [2021-11-04]

### Warning

This is the last release supporting Python 2.

- `mpi4py.futures`: Add `_max_workers` property to `MPILoopExecutor`.
- `mpi4py.util.dtlb`: Fix computation of alignment for predefined datatypes.
- `mpi4py.util.pk15`: Fix deadlock when using `ssend()` + `mprobe()`.
- `mpi4py.util.pk15`: 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).

## 17.8 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.

## 17.9 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.



## 17.10 Release 3.0.3 [2019-11-04]

- Regenerate Cython wrappers to support Python 3.8.

## 17.11 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.

## 17.12 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.

## 17.13 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.

## 17.14 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`.

### 17.15 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`.

### 17.16 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 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.

### 17.17 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`.

### 17.18 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.

### 17.19 Release 1.2 [2009-12-29]

- Automatic MPI datatype discovery for NumPy arrays and PEP-3118 buffers. Now buffer-like objects can be mesaged 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.

## 17.20 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.

## 17.21 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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