

TcIMPI

1.1

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# Chapter 1

## Main Page

The TcIMPI package contains software that wraps an MPI library for Tcl and allows MPI calls to be used from Tcl scripts. This code can be compiled as a shared object to be loaded into an existing Tcl interpreter or as a standalone TcIMPI interpreter. In combination with some additional bundled Tcl script code, additional commands are provided that allow to run Tcl scripts in parallel via "mpirun" or "mpiexec" similar to C, C++ or Fortran programs.

### 1.0.1 Homepage:

The main author of this package is Axel Kohlmeyer and you can reach him at [akohlmey@gmail.com](mailto:akohlmey@gmail.com). The official homepage for this project is <https://akohlmey.github.io/tclmpi/> and development is hosted on GitHub.

For compilation and installation instructions, please see the file INSTALL. Detailed documentation is available online from the project home page and [as a PDF file in the source package](#).

### 1.0.2 Test Status:

### 1.0.3 Citing:

You can cite TcIMPI as:

Axel Kohlmeyer. (2021). TcIMPI: Release 1.1 [Data set]. Zenodo.

### 1.0.4 Acknowledgements:

Thanks to Arjen Markus and Chris MacDermaid for encouragement and (lots of) constructive criticism, that has helped enormously to develop the package from a crazy idea to its current level. Thanks to Alex Baker for motivating me to convert to using CMake as build system which makes building TcIMPI natively on Windows much easier.

A special thanks also goes to Karolina Sarnowska-Upton and Andrew Grimshaw that allowed me to use TcIMPI as an example in their MPI portability study, which helped to find quite a few bugs and resolve several portability issues before the code was hitting the real world.





## Chapter 2

# Copyright and License for TcIMPI

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## Chapter 3

# TclMPI User's Guide

This page describes Tcl bindings for MPI. This package provides a shared object that can be loaded into a Tcl interpreter to provide additional commands that act as an interface to an underlying MPI implementation. This allows to run Tcl scripts in parallel via `mpirun` or `mpiexec` similar to C, C++ or Fortran programs and communicate via wrappers to MPI function call.

The original motivation for writing this package was to complement a Tcl wrapper for the LAMMPS molecular dynamics simulation software, but also allow using the VMD molecular visualization and analysis package in parallel without having to recompile VMD and using a convenient API to people that already know how to program parallel programs with MPI in C, C++ or Fortran.

### 3.1 Compilation and Installation

The package currently consist of a single C source file which usually will be compiled for dynamic linkage, but can also be compiled into a new Tcl interpreter with TclMPI included (required on some platforms that require static linkage) and a Tcl script file. In addition the package contains some examples, a simple unit test harness (implemented in Tcl) and a set of tests to be run with either one MPI rank (`test01`, `test02`) or two MPI ranks (`test03`, `test04`).

The build system uses CMake (version 3.16 or later) and has been confirmed to work on Linux macOS and Windows. The MPI library has to be at least MPI-2 standard compliant and the Tcl version should be 8.6 or later (it may work with 8.5, too). When compiled for a dynamically loaded shared object (DSO) or DLL file, the MPI library has to be compiled and linked with support for building shared libraries as well (this is the default for OpenMPI on Linux, but your mileage may vary).

To configure and build TclMPI you need to run CMake the usual way, for example with

```
cmake -B build-folder -S .
cmake --build build-folder
cmake --install build-folder
```

There are a few settings that can be used to adjust what is compiled and installed and where. The following settings are supported:

- `BUILD_TCLMPI_SHELL` Build a `tclmpish` executable as extended Tcl shell (default: on)
- `ENABLE_TCL_STUBS` Use the Tcl stubs mechanism (default: on, requires Tcl 8.6 or later)
- `BUILD_TESTING` Enable unit testing (default: on)
- `DOWNLOAD_MPICH4WIN` Download MPICH2-1.4.1 headers and link library (default: off, Windows only)

- CMAKE\_INSTALL\_PREFIX Path to installation location prefix (default: (platform specific))

To change settings from the defaults append `-D<SETTING>=<VALUE>` to the `cmake` command line and replace `<SETTING>` and `<VALUE>` accordingly.

To enable the new TclMPI package you can use the command `set auto_path [concat /usr/local/tcl8.6/$auto_path]` in your `.tclshrc` (or `.vmdrc` or similar) file and then you can load the TclMPI wrappers on demand simply by using the command `package require tclmpi`. For the extended shell, the `_tclmpi.so` file is not used and instead `tclmpish` needs to run instead of `tclsh`. For that you may append the `bin` folder of the installation tree to your `PATH` environment variable. In case of using the custom Tcl shell, the startup script would be called `.tclmpishrc` instead of `.tclshrc`.

## 3.2 Software Development and Bug Reports

The TclMPI code is maintained using git for source code management, and the project is hosted on github at <https://github.com/akohlmeier/tclmpi>. From there you can download snapshots of the development and releases, clone the repository to follow development, or work on your own branch through forking it. Bug reports and feature requests should also be filed on github at through the issue tracker at: <https://github.com/akohlmeier/tclmpi/issues>.

## 3.3 Example Programs

The following section provides some simple examples using TclMPI to recreate some common MPI example programs in Tcl.

### 3.3.1 Hello World

This is the TclMPI version of "hello world".

```
#!/bin/sh \
exec tclsh "$0" "$@"
package require tclmpi 0.9
# initialize MPI
::tclmpi::init
# get size of communicator and rank of process
set comm tclmpi::comm_world
set size [::tclmpi::comm_size $comm]
set rank [::tclmpi::comm_rank $comm]
puts "hello world, this is rank $rank of $size"
# shut down MPI
::tclmpi::finalize
exit 0
```

### 3.3.2 Computation of Pi

This script uses TclMPI to compute the value of Pi from numerical quadrature of the integral:

$$\pi = \int_0^1 \frac{4}{1+x^2} dx$$

```
#!/bin/sh \
exec tclsh "$0" "$@"
package require tclmpi 0.9
# initialize MPI
::tclmpi::init
set comm tclmpi::comm_world
set size [::tclmpi::comm_size $comm]
```

```

set rank [::tclmpi::comm_rank $comm]
set master 0
set num [lindex $argv 0]
# make sure all processes have the same interval parameter
set num [::tclmpi::bcast $num ::tclmpi::int $master $comm]
# run parallel calculation
set h [expr {1.0/$num}]
set sum 0.0
for {set i $rank} {$i < $num} {incr i $size} {
    set sum [expr {$sum + 4.0/(1.0 + ($h*($i+0.5))*2)}]
}
set mypi [expr {$h * $sum}]
# combine and print results
set mypi [::tclmpi::allreduce $mypi tclmpi::double \
    tclmpi::sum $comm]
if {$rank == $master} {
    set rel [expr {abs(($mypi - 3.14159265358979)/3.14159265358979)}]
    puts "result: $mypi. relative error: $rel"
}
# shut down MPI
::tclmpi::finalize
exit 0

```

### 3.3.3 Distributed Sum

This is a small example version that distributes a data set and computes the sum across all elements in parallel.

```

#!/bin/sh \
exec tclsh "$0" "$@"
package require tclmpi 0.9
# data summation helper function
proc sum {data} {
    set sum 0
    foreach d $data {
        set sum [expr {$sum + $d}]
    }
    return $sum
}
::tclmpi::init
set comm $tclmpi::comm_world
set mpi_sum $tclmpi::sum
set mpi_double $tclmpi::double
set mpi_int $tclmpi::int
set size [::tclmpi::comm_size $comm]
set rank [::tclmpi::comm_rank $comm]
set master 0
# The master creates the list of data
#
set dataSize 1000000
set data {}
if { $comm == $master } {
    set mysum 0
    for { set i 0 } { $i < $dataSize } { incr i } {
        lappend data $i
    }
}
# add padding, so the number of data elements is divisible
# by the number of processors as required by tclmpi::scatter
set needpad [expr {$dataSize % $size}]
set numpad [expr {$needpad ? ($size - $needpad) : 0}]
if { [comm_rank $comm] == $master } {
    for {set i 0} {$i < $numpad} {incr i} {
        lappend data 0
    }
}
set blocksz [expr {($dataSize + $numpad) / $size}]
# distribute data and do the summation on each node
# the sum the result across all nodes. Note: the data
# is integer, but we need to do the full sum in double
# precision to avoid overflows.
set mydata [::tclmpi::scatter $data $mpi_int $master $comm]
set sum [::tclmpi::allreduce [sum $mydata] $mpi_double $mpi_sum $comm]
if { $comm == $master } {
    puts "Distributed sum: $sum"
}
::tclmpi::finalize

```



## Chapter 4

# TclMPI Developer's Guide

This document explains the implementation of the Tcl bindings for MPI implemented in TclMPI. The following sections will document how and which MPI is mapped to Tcl and what design choices were made.

### 4.1 Overall Design and Differences to the MPI C-bindings

To be consistent with typical Tcl conventions all commands and constants in lower case and prefixed with `tclmpi`, so that clashes with existing programs are reduced. This is not yet set up to be a proper namespace, but that may happen at a later point, if the need arises. The overall philosophy of the bindings is to make the API similar to the MPI one (e.g. maintain the order of arguments), but don't stick to it slavishly and do things the Tcl way wherever justified. Convenience and simplicity take precedence over performance. If performance matters that much, one would write the entire code C/C++ or Fortran and not Tcl. The biggest visible change is that for sending data around, receive buffers will be automatically set up to handle the entire message. Thus the typical "count" arguments of the C/C++ or Fortran bindings for MPI is not required, and the received data will be the return value of the corresponding command. This is consistent with the automatic memory management in Tcl, but this convenience and consistency will affect performance and the semantics. For example calls to `tclmpi::bcast` will be converted into *two* calls to `MPI_Bcast()`; the first will broadcast the size of the data set being sent (so that a sufficiently sized buffers can be allocated) and then the second call will finally send the data for real. Similarly, `tclmpi::recv` will be converted into calling `MPI_Probe()` and then `MPI_Recv()` for the purpose of determining the amount of temporary storage required. The second call will also use the `MPI_SOURCE` and `MPI_TAG` flags from the `MPI_Status` object created for `MPI_Probe()` to make certain, the correct data is received.

Things get even more complicated with with non-blocking receives. Since we need to know the size of the message to receive, a non-blocking receive can only be posted, if the corresponding send is already pending. This is being determined by calling `MPI_Iprobe()` and when this shows no (matching) pending message, the parameters for the receive will be cached and the then `MPI_Probe()` followed by `MPI_Recv()` will be called as part of `tclmpi::wait`. The blocking/non-blocking behavior of the Tcl script should be very close to the corresponding C bindings, but probably not as efficient.

### 4.2 Naming Conventions

All functions that are new Tcl commands follow the MPI naming conventions, but using `TclMPI_` as prefix instead of `MPI_`. The corresponding Tcl commands are placed in the `tclmpi` namespace and all lower case. Example: `TclMPI_Init()` is the wrapper for `MPI_Init()` and is provided as command `tclmpi::init`. Defines and constants from the MPI header file are represented in TclMPI as plain strings, all lowercase and with a `tclmpi::` prefix. Thus `MPI_COMM_WORLD` becomes `tclmpi::comm_world` and `MPI_INT` becomes `tclmpi::int`.

Functions that are internal to the plugin as well as static variables are prefixed with all lower case, i.e. `tcimpi_`. Those functions have to be declared static.

All string constants are also declared as namespace variables, e.g. `$tcimpi::comm_world`, so that shortcut notations are possible as shown in the following example:

```
namespace upvar tcimpi comm_world comm
namespace upvar tcimpi int mpi_int
```

## 4.3 TclMPI Support Functions

Several MPI entities like communicators, requests, status objects cannot be represented directly in Tcl. For TclMPI they need to be mapped to something else, for example a string that will uniquely identify this entity and then it will be translated into the real object it represents with the help of the following support functions.

### 4.3.1 Mapping MPI Communicators

MPI communicators are represented in TclMPI by strings of the form `"tcimpi::comm%d"`, with `"%d"` being replaced by a unique integer. In addition, a few string constants are mapped to the default communicators that are defined in MPI. These are `tcimpi::comm_world`, `tcimpi::comm_self`, and `tcimpi::comm_null`, which represent `MPI_COMM_WORLD`, `MPI_COMM_SELF`, and `MPI_COMM_NULL`, respectively.

Internally the map is maintained in a simple linked list which is initialized with the three default communicators when the plugin is loaded and where new communicators are added at the end as needed. The functions `mpi2tcl_comm` and `tcl2mpi_comm` are then used to translate from one representation to the other while `tcimpi_add_comm` will append a new structure containing the communicator to the list. Correspondingly `tcimpi_del_comm` will remove a communicator entry from the list, based on its Tcl string representation.

### 4.3.2 Mapping MPI Requests

MPI requests are represented in TclMPI by strings of the form `"tcimpi::req%d"`, with `"%d"` being replaced by a unique integer. Internally this map is maintained in a simple linked list to which new requests are appended and from which completed requests are removed as needed. The function `tcimpi_find_req` is used to locate a specific request and its associated data from its string label. In addition, `tcimpi_add_req` will append a new request to the list, and `tcimpi_del_req` will remove (completed) requests.

### 4.3.3 Mapping Data Types

The helper function `tcimpi_datatype` is used to convert string constants representing specific data types into integer constants for convenient branching. Data types in TclMPI are somewhat different from MPI data types to match better the spirit of Tcl scripting.

### 4.3.4 Common Error Message Processing

There is a significant redundancy in checking for and reporting error conditions. For this purpose, several support functions exist.

`tcimpi_errcheck` verifies if calls to the MPI library were successful and if not, generates a formatted error message that is appended to the current result list.

`tcimpi_commcheck` verifies if a communicator argument was using a valid Tcl representation and if not, generates a formatted error message that is appended to the current result list.

`tcimpi_typecheck` test if a type argument was using a valid Tcl representation and if not, generates a formatted error message that is appended to the current result list.



## Chapter 5

# Namespace Index

### 5.1 Namespace List

Here is a list of all documented namespaces with brief descriptions:

<a href="#">tclmpi</a> . . . . .	17
----------------------------------	----



## Chapter 6

# Class Index

### 6.1 Class List

Here are the classes, structs, unions and interfaces with brief descriptions:

<a href="#">tclmpi_comm</a>	31
<a href="#">tclmpi_dblint</a>	32
<a href="#">tclmpi_intint</a>	33
<a href="#">tclmpi_req</a>	34



## Chapter 7

# File Index

### 7.1 File List

Here is a list of all documented files with brief descriptions:

<a href="#">_tclmpi.c</a>	This file contains the C code with the Tcl MPI wrappers . . . . .	37
<a href="#">harness.tcl</a>	This file contains the TcIMPI test harness script code . . . . .	56
<a href="#">tclmpi.tcl</a>	This file contains the Tcl script parts of the tclmpi namespace and the embedded documentation of the Tcl API of TcIMPI . . . . .	56



## Chapter 8

# Namespace Documentation

### 8.1 tclmpi Namespace Reference

#### Functions

- proc [init](#) ()
- proc [conv\\_set](#) (handler)
- proc [conv\\_get](#) (handler)
- proc [finalize](#) ()
- proc [abort](#) (comm, errorcode)
- proc [comm\\_size](#) (comm)
- proc [comm\\_rank](#) (comm)
- proc [comm\\_split](#) (comm, color, key)
- proc [comm\\_free](#) (comm)
- proc [barrier](#) (comm)
- proc [bcast](#) (data, type, root, comm)
- proc [scatter](#) (data, type, root, comm)
- proc [allgather](#) (data, type, comm)
- proc [gather](#) (data, type, root, comm)
- proc [allreduce](#) (data, type, op, comm)
- proc [reduce](#) (data, type, op, root, comm)
- proc [send](#) (data, type, dest, tag, comm)
- proc [isend](#) (data, type, dest, tag, comm)
- proc [recv](#) (type, source, tag, comm, status={})
- proc [irecv](#) (type, source, tag, comm)
- proc [probe](#) (source, tag, comm, status={})
- proc [wait](#) (request, status={})
- proc [waitall](#) (requests, status={})

#### Variables

- variable [version](#) = "1.1"  
*version number of this package*
- variable [auto](#) = tclmpi::auto  
*constant for automatic data type*
- variable [int](#) = tclmpi::int

- constant for integer data type*
  - variable `intint` = `tlcMpi::intint`
- constant for integer pair data type*
  - variable `double` = `tlcMpi::double`
- constant for double data type*
  - variable `dblnt` = `tlcMpi::dblnt`
- constant for double/int pair data type*
  - variable `comm_world` = `tlcMpi::comm_world`
- constant for world communicator*
  - variable `comm_self` = `tlcMpi::comm_self`
- constant for self communicator*
  - variable `comm_null` = `tlcMpi::comm_null`
- constant empty communicator*
  - variable `any_source` = `tlcMpi::any_source`
- constant to accept messages from any source rank*
  - variable `any_tag` = `tlcMpi::any_tag`
- constant to accept messages with any tag*
  - variable `sum` = `tlcMpi::sum`
- summation operation*
  - variable `prod` = `tlcMpi::prod`
- product operation*
  - variable `max` = `tlcMpi::max`
- maximum operation*
  - variable `min` = `tlcMpi::min`
- minimum operation*
  - variable `land` = `tlcMpi::land`
- logical and operation*
  - variable `band` = `tlcMpi::band`
- bitwise and operation*
  - variable `lor` = `tlcMpi::lor`
- logical or operation*
  - variable `bor` = `tlcMpi::bor`
- bitwise or operation*
  - variable `lxor` = `tlcMpi::lxor`
- logical xor operation*
  - variable `bxor` = `tlcMpi::bxor`
- bitwise xor operation*
  - variable `maxloc` = `tlcMpi::maxloc`
- maximum and location operation*
  - variable `minloc` = `tlcMpi::minloc`
- minimum and location operation*
  - variable `error` = `tlcMpi::error`
- throw a Tcl error when a data conversion fails*
  - variable `abort` = `tlcMpi::abort`
- call MPI\_Abort() when a data conversion fails*
  - variable `tozero` = `tlcMpi::tozero`
- silently assign zero for failed data conversions*
  - variable `undefined` = `tlcMpi::undefined`
- constant to indicate an undefined number*



### 8.1.1 Detailed Description

TclMPI package Tcl namespace

### 8.1.2 Function Documentation

#### 8.1.2.1 abort()

```
proc tclmpi::abort (  
    comm ,  
    errorcode )
```

Terminates the MPI environment from Tcl

##### Parameters

<i>comm</i>	Tcl representation of an MPI communicator
<i>errorcode</i>	an integer that will be returned as exit code to the OS

This command makes a best attempt to abort all tasks sharing the communicator and exit with the provided error code. Only one task needs to call [tclmpi::abort](#). This command terminates the program, so there can be no return value.

For implementation details see [TclMPI\\_Abort\(\)](#).

#### 8.1.2.2 allgather()

```
proc tclmpi::allgather (  
    data ,  
    type ,  
    comm )
```

Collects data from all processes on the communicator

##### Parameters

<i>data</i>	data to be distributed (Tcl data object)
<i>type</i>	data type to be used (string constant)
<i>comm</i>	Tcl representation of an MPI communicator

##### Returns

data that was collected or empty

This command collects data the provided list from all processes sharing the communicator. The data argument has to be present on all processes and has to be of the same length. The data resulting from the gather will be stored in the return value of the command for all processes. This function call is an implicit synchronization.

For implementation details see [TclMPI\\_Allgather\(\)](#).

### 8.1.2.3 allreduce()

```
proc tclmpi::allreduce (
    data ,
    type ,
    op ,
    comm )
```

Combines data from all processes and distributes the result back to them

#### Parameters

<i>data</i>	data to be reduced (Tcl data object)
<i>type</i>	data type to be used (string constant)
<i>op</i>	reduction operation (string constant)
<i>comm</i>	Tcl representation of an MPI communicator

#### Returns

data resulting from the reduction operation

This command performs a global reduction operation *op* on the provided data object across all processes participating in the communicator *comm*. If data is a list, then the reduction will be done across each respective entry of the same list index. The result is distributed to all processes and used as return value of the command. This command only supports the data types [tclmpi::int](#) and [tclmpi::double](#) and [tclmpi::intint](#) for operations [tclmpi::maxloc](#) and [tclmpi::minloc](#). The following reduction operations are supported: [tclmpi::max](#) (maximum), [tclmpi::min](#) (minimum), [tclmpi::sum](#) (sum), [tclmpi::prod](#) (product), [tclmpi::land](#) (logical and), [tclmpi::band](#) (bitwise and), [tclmpi::lor](#) (logical or), [tclmpi::bor](#) (bitwise or), [tclmpi::lxor](#) (logical exclusive or), [tclmpi::bxor](#) (bitwise exclusive or), [tclmpi::maxloc](#) (max value and location), [tclmpi::minloc](#) (min value and location). This function call is an implicit synchronization.

For implementation details see [TclMPI\\_Allreduce\(\)](#).

### 8.1.2.4 barrier()

```
proc tclmpi::barrier (
    comm )
```

Synchronize MPI processes

#### Parameters

<i>comm</i>	Tcl representation of an MPI communicator
-------------	---

Blocks the caller until all processes sharing the communicator have called it; the call returns at any process only after **all** processes have entered the call and thus effectively synchronizes the processes. This function has no return value.

For implementation details see [TclMPI\\_Barrier\(\)](#).

### 8.1.2.5 bcast()

```
proc tclmpi::bcast (
    data ,
    type ,
    root ,
    comm )
```

Broadcasts data from one process to all processes on the communicator

#### Parameters

<i>data</i>	data to be broadcast (Tcl data object)
<i>type</i>	data type to be used (string constant)
<i>root</i>	rank of process that is providing the data (integer)
<i>comm</i>	Tcl representation of an MPI communicator

#### Returns

data that was broadcast

This command broadcasts the provided data object (list or single number or string) from the process with rank *root* on the communicator *comm* to all processes sharing the communicator. The data argument has to be present on all processes but will be ignored on all but the root process. The data resulting from the broadcast will be stored in the return value of the command on **all** processes. This is important when the data type is not `tclmpi::auto`, since using other data types may incur an irreversible conversion of the data elements. This function call is an implicit synchronization.

For implementation details see [TclMPI\\_Bcast\(\)](#).

### 8.1.2.6 comm\_free()

```
proc tclmpi::comm_free (
    comm )
```

Deletes a dynamically created communicator and frees its resources

#### Parameters

<i>comm</i>	Tcl representation of an MPI communicator
-------------	---

This operation marks the MPI communicator associated with it Tcl representation *comm* for deallocation by the underlying MPI library. Any pending communications using this communicator will still complete normally.

For implementation details see [TclMPI\\_Comm\\_free\(\)](#).

### 8.1.2.7 comm\_rank()

```
proc tclmpi::comm_rank (
    comm )
```

Returns the rank of the current process in an MPI communicator

**Parameters**

<i>comm</i>	Tcl representation of an MPI communicator
-------------	---

**Returns**

rank on the communicator (integer between 0 and size-1)

This function gives the rank of the process in the particular communicator. Many programs will be written with a manager-worker model, where one process (such as the rank-zero process) will play a supervisory role, and the other processes will serve as compute nodes. In this framework, [tclmpi::comm\\_size](#) and [tclmpi::comm\\_rank](#) are useful for determining the roles of the various processes of a communicator.

For implementation details see [TclMPI\\_Comm\\_rank\(\)](#).

**8.1.2.8 comm\_size()**

```
proc tclmpi::comm_size (
    comm )
```

Returns the number of processes involved in an MPI communicator

**Parameters**

<i>comm</i>	Tcl representation of an MPI communicator
-------------	---

**Returns**

number of MPI processes on communicator

This function indicates the number of processes involved in a communicator. For [tclmpi::comm\\_world](#), it indicates the total number of processes available. This call is often used in combination with [tclmpi::comm\\_rank](#) to determine the amount of concurrency available for a specific library or program. [tclmpi::comm\\_rank](#) indicates the rank of the process that calls it in the range from 0...size-1, where size is the return value of [tclmpi::comm\\_size](#).

For implementation details see [TclMPI\\_Comm\\_size\(\)](#).

**8.1.2.9 comm\_split()**

```
proc tclmpi::comm_split (
    comm ,
    color ,
    key )
```

Creates new communicators based on "color" and "key" flags

**Parameters**

<i>comm</i>	Tcl representation of an MPI communicator
<i>color</i>	subset assignment (non-negative integer or <a href="#">tclmpi::undefined</a> )
<i>key</i>	relative rank assignment (integer)

**Returns**

Tcl representation of the newly created MPI communicator

This function partitions the group associated with `comm` into disjoint subgroups, one for each value of `color`. Each subgroup contains all processes of the same color. Within each subgroup, the processes are ranked in the order defined by the value of the argument `key`, with ties broken according to their rank in the old group. A new communicator is created for each subgroup and returned in `newcomm`. A process may supply the color value `tclmpi::undefined`, in which case the function returns `tclmpi::comm_null`. This is a collective call, but each process is permitted to provide different values for `color` and `key`.

The following example shows how to construct a communicator where the ranks are reversed in comparison to the world communicator.

```
set comm tclmpi::comm_world
set size [::tclmpi::comm_size $comm]
set key -[::tclmpi::comm_rank $comm]
set revcomm [::tclmpi::comm_split $comm 1 $key]
```

For implementation details see [TclMPI\\_Comm\\_split\(\)](#).

**8.1.2.10 conv\_get()**

```
proc tclmpi::conv_get (
    handler )
```

Return a string constant naming the error handler for TclMPI data conversions

**Returns**

string constant for error handler

This function allows to query which error handler is currently active for Tcl data conversions inside TclMPI. For details on the error handlers, see [tclmpi::conv\\_set](#).

For implementation details see [TclMPI\\_Conv\\_get\(\)](#).

**8.1.2.11 conv\_set()**

```
proc tclmpi::conv_set (
    handler )
```

Set the error handler for TclMPI data conversions

**Parameters**

<i>handler</i>	string constant for error handler
----------------	-----------------------------------

This function sets what action TclMPI should take if a data conversion to `tclmpi::int` or `tclmpi::double` fails. When using data types other than `tclmpi::auto`, the corresponding data needs to be converted from the internal Tcl representation to the selected native format. However, this does not always succeed for a variety of reasons. With this function TclMPI allows the programmer to define how this is handled. There are currently three handlers available: `tclmpi::error` (the default setting), `tclmpi::abort`, and `tclmpi::tozero`. For `tclmpi::error` a Tcl error is raised that can be intercepted with `catch` and TclMPI immediately returns to the calling function. For `tclmpi::abort` an error message is

written directly to the screen and parallel execution on the current communicator is terminated via `MPI_Abort()`. For `tclmpi::tozero` the error is silently ignored and the data element set to zero. This command has no return value.

For implementation details see [TclMPI\\_Conv\\_set\(\)](#).

#### 8.1.2.12 finalize()

```
proc tclmpi::finalize ( )
```

Shut down the MPI environment from Tcl

This command closes the MPI environment and cleans up all MPI states. All processes must call this routine before exiting. Calling this function before calling `tclmpi::init` is an error. After calling this function, no more TclMPI commands including `tclmpi::finalize` and `tclmpi::init` may be used. This command takes no arguments and has no return value.

For implementation details see [TclMPI\\_Finalize\(\)](#).

#### 8.1.2.13 gather()

```
proc tclmpi::gather (
    data ,
    type ,
    root ,
    comm )
```

Collects data from all processes on the communicator

##### Parameters

<i>data</i>	data to be distributed (Tcl data object)
<i>type</i>	data type to be used (string constant)
<i>root</i>	rank of process that will receive the data (integer)
<i>comm</i>	Tcl representation of an MPI communicator

##### Returns

data that was collected or empty

This command collects data the provided list from the process with rank `root` on the communicator `comm` to all processes sharing the communicator. The `data` argument has to be present on all processes and has to be of the same length. The data resulting from the `gather` will be stored in the return value of the command on the root process. This function call is an implicit synchronization. This procedure is the reverse operation of `tclmpi::scatter`.

For implementation details see [TclMPI\\_Gather\(\)](#).

#### 8.1.2.14 init()

```
proc tclmpi::init ( )
```

Initialize the MPI environment from Tcl

This command initializes the MPI environment. Needs to be called before any other TclMPI commands. MPI can be initialized at most once, so calling [tclmpi::init](#) multiple times is an error. Like in the C bindings for MPI, [tclmpi::init](#) will scan the argument vector, the global variable \$argv, for any MPI implementation specific flags and will remove them. The global variable \$argc will be adjusted accordingly. This command takes no arguments and has no return value.

For implementation details see [TclMPI\\_Init\(\)](#).

#### 8.1.2.15 irecv()

```
proc tclmpi::irecv (
    type ,
    source ,
    tag ,
    comm )
```

Initiate a non-blocking receive

##### Parameters

<i>type</i>	data type to be used (string constant)
<i>source</i>	rank of sending process or <a href="#">tclmpi::any_source</a>
<i>tag</i>	message identification tag or <a href="#">tclmpi::any_tag</a>
<i>comm</i>	Tcl representation of an MPI communicator

##### Returns

Tcl representation of generated MPI request

This procedure provides a non-blocking receive operation, i.e. it returns **immediately**. The call does not return any data but a request handle of the form `tclmpi::req#`, with # being a unique integer number. This request handle is best stored in a variable and needs to be passed to a [tclmpi::wait](#) call to wait for completion of the receive and pass the data to the calling code as return value of the wait call. The type argument has to match that of the corresponding send command. Instead of a specific source rank, the constant [tclmpi::any\\_source](#) can be used and similarly [tclmpi::any\\_tag](#) as tag, to not select on source rank or tag, respectively.

For implementation details see [TclMPI\\_Irecv\(\)](#).

#### 8.1.2.16 isend()

```
proc tclmpi::isend (
    data ,
    type ,
    dest ,
    tag ,
    comm )
```

Perform a non-blocking send

**Parameters**

<i>data</i>	data to be sent (Tcl data object)
<i>type</i>	data type to be used (string constant)
<i>dest</i>	rank of destination process (non-negative integer)
<i>tag</i>	message identification tag (integer)
<i>comm</i>	Tcl representation of an MPI communicator

**Returns**

Tcl representation of generated MPI request

This function performs a regular **non-blocking** send to process rank *dest* on communicator *comm*. The choice of data type determines how data is being sent and thus unlike in the C-bindings the corresponding receive has to use the same data type. As a non-blocking call, the function will return immediately. The return value is a string representing the generated MPI request and it can be passed to a call to [tclmpi::wait](#) in order to wait for its completion and release all reserved storage associated with the request.

For implementation details see [TclMPI\\_Isend\(\)](#).

**8.1.2.17 probe()**

```
proc tclmpi::probe (
    source ,
    tag ,
    comm ,
    status = {} )
```

Blocking test for a message

**Parameters**

<i>source</i>	rank of sending process or <a href="#">tclmpi::any_source</a>
<i>tag</i>	message identification tag or <a href="#">tclmpi::any_tag</a>
<i>comm</i>	Tcl representation of an MPI communicator
<i>status</i>	variable name for status array (string)

**Returns**

empty

This function allows to check for an incoming message on the communicator *comm* without actually receiving it. Nevertheless, this call is blocking, i.e. it will not return unless there is actually a message pending that matches the requirements of source rank and message tag. Instead of a specific source rank, the constant [tclmpi::any\\_source](#) can be used and similarly [tclmpi::any\\_tag](#) as tag, to accept send requests from any rank or tag, respectively. The (optional) status argument would be the name of a variable in which status information about the message will be stored in the form of an array. This associative array has the entries MPI\_SOURCE (rank of sender), MPI\_TAG (tag of message), COUNT\_CHAR (size of message in bytes), COUNT\_INT (size of message in [tclmpi::int](#) units), COUNT\_DOUBLE (size of message in [tclmpi::double](#) units).

For implementation details see [TclMPI\\_Probe\(\)](#).



### 8.1.2.18 recv()

```

proc tclmpi::recv (
    type ,
    source ,
    tag ,
    comm ,
    status = {} )

```

Perform a blocking receive

#### Parameters

<i>type</i>	data type to be used (string constant)
<i>source</i>	rank of sending process or <a href="#">tclmpi::any_source</a>
<i>tag</i>	message identification tag or <a href="#">tclmpi::any_tag</a>
<i>comm</i>	Tcl representation of an MPI communicator
<i>status</i>	variable name for status array (string)

#### Returns

the received data

This procedure provides a blocking receive operation, i.e. it only returns **after** the message is received in full. The received data will be passed as return value. The type argument has to match that of the corresponding send command. Instead of using a specific source rank, the constant [tclmpi::any\\_source](#) can be used and similarly [tclmpi::any\\_tag](#) as tag. This way the receive operation will not select a message based on source rank or tag, respectively. The (optional) status argument would be the name of a variable in which status information about the receive will be stored in the form of an array. The associative array has the entries MPI\_SOURCE (rank of sender), MPI\_TAG (tag of message), COUNT\_CHAR (size of message in bytes), COUNT\_INT (size of message in [tclmpi::int](#) units), COUNT\_DOUBLE (size of message in [tclmpi::double](#) units).

For implementation details see [TclMPI\\_Recv\(\)](#).

### 8.1.2.19 reduce()

```

proc tclmpi::reduce (
    data ,
    type ,
    op ,
    root ,
    comm )

```

Combines data from all processes on one process

#### Parameters

<i>data</i>	data to be reduced (Tcl data object)
<i>type</i>	data type to be used (string constant)
<i>op</i>	reduction operation (string constant)
<i>root</i>	rank of process that is receiving the result (integer)
<i>comm</i>	Tcl representation of an MPI communicator

**Returns**

data resulting from the reduction operation

This command performs a global reduction operation on the provided data object across all processes participating in the communicator `comm`. If data is a list, then the reduction will be done across each respective entry of the same list index. The result is collected on the process with rank `root` and used as the return value of the command. For all other processes the return value is empty. This command only supports the data types `tcimpi::int` and `tcimpi::double` and `tcimpi::intint` for operations `tcimpi::maxloc` and `tcimpi::minloc`. The following reduction operations are supported: `tcimpi::max` (maximum), `tcimpi::min` (minimum), `tcimpi::sum` (sum), `tcimpi::prod` (product), `tcimpi::land` (logical and), `tcimpi::band` (bitwise and), `tcimpi::lor` (logical or), `tcimpi::bor` (bitwise or), `tcimpi::lxor` (logical exclusive or), `tcimpi::bxor` (bitwise exclusive or), `tcimpi::maxloc` (max value and location), `tcimpi::minloc` (min value and location). This function call is an implicit synchronization.

For implementation details see [TcIMPI\\_Reduce\(\)](#).

**8.1.2.20 scatter()**

```
proc tcimpi::scatter (
    data ,
    type ,
    root ,
    comm )
```

Distributes data from one process to all processes on the communicator

**Parameters**

<i>data</i>	data to be distributed (Tcl data object)
<i>type</i>	data type to be used (string constant)
<i>root</i>	rank of process that is providing the data (integer)
<i>comm</i>	Tcl representation of an MPI communicator

**Returns**

data that was distributed

This command distributes the provided list of data from the process with rank `root` on the communicator `comm` to all processes sharing the communicator. The data argument has to be present on all processes but will be ignored on all but the root process. The data resulting from the scatter will be stored in the return value of the command. The data will be distributed evenly, so the length of the list has to be divisible by the number of processes on the communicator. This procedure is the reverse operation of [tcimpi::gather](#). This function call is an implicit synchronization.

For implementation details see [TcIMPI\\_Scatter\(\)](#).

**8.1.2.21 send()**

```
proc tcimpi::send (
    data ,
    type ,
    dest ,
    tag ,
    comm )
```

Perform a blocking send

## Parameters

<i>data</i>	data to be sent (Tcl data object)
<i>type</i>	data type to be used (string constant)
<i>dest</i>	rank of destination process (non-negative integer)
<i>tag</i>	message identification tag (integer)
<i>comm</i>	Tcl representation of an MPI communicator

This function performs a regular **blocking** send to process rank *dest* on communicator *comm*. The choice of data type determines how data is being sent and thus unlike in the C-bindings the corresponding receive has to use the same data type. As a blocking call, the function will only return when all data is sent. This function has no return value.

For implementation details see [TclMPI\\_Send\(\)](#).

**8.1.2.22 wait()**

```
proc tclmpi::wait (
    request ,
    status = {} )
```

Non-blocking test for a message

## Parameters

<i>source</i>	rank of sending process or <a href="#">tclmpi::any_source</a>
<i>tag</i>	message identification tag or <a href="#">tclmpi::any_tag</a>
<i>comm</i>	Tcl representation of an MPI communicator
<i>status</i>	variable name for status array (string)

## Returns

1 or 0 depending on whether a pending request was detected

This function allows to check for an incoming message on the communicator *comm* without actually receiving it. Unlike [tclmpi::probe](#), this call is non-blocking, i.e. it will return immediately and report whether there is a message pending or not in its return value (1 or 0, respectively). Instead of a specific source rank, the constant [tclmpi::any\\_source](#) can be used and similarly [tclmpi::any\\_tag](#) as tag, to test for send requests from any rank or tag, respectively. The (optional) status argument would be the name of a variable in which status information about the message will be stored in the form of an array. This associative array has the entries MPI\_SOURCE (rank of sender), MPI\_TAG (tag of message), COUNT\_CHAR (size of message in bytes), COUNT\_INT (size of message in [tclmpi::int](#) units), COUNT\_DOUBLE (size of message in [tclmpi::double](#) units).

For implementation details see [TclMPI\\_lprobe\(\)](#). Wait for MPI request completion

## Parameters

<i>request</i>	Tcl representation of an MPI request
<i>status</i>	variable name for status array (string)

**Returns**

empty or received data that was associated with the request

This function takes a communication request created by a non-blocking send or receive call ([tclmpi::isend](#) or [tclmpi::irecv](#)) and waits for its completion. In case of a send, it will merely wait until the matching communication is completed and any resources associated with the request will be released. If the request was generated by a non-blocking receive call, [tclmpi::wait](#) will hand the received data to the calling routine in its return value. The (optional) status argument would be the name of a variable in which the resulting status information will be stored in the form of an associative array. The associative array will have the entries MPI\_SOURCE (rank of sender), MPI\_TAG (tag of message), COUNT\_CHAR (size of message in bytes), COUNT\_INT (size of message in [tclmpi::int](#) units), COUNT\_DOUBLE (size of message in [tclmpi::double](#) units).

For implementation details see [TclMPI\\_Wait\(\)](#).

**8.1.2.23 waitall()**

```
proc tclmpi::waitall (
    requests ,
    status = {} )
```

Wait for multiple MPI request completions

**Parameters**

<i>requests</i>	List of Tcl representations of an MPI request
<i>status</i>	variable name for array with list of statuses (string)

**Returns**

empty or list of received data that was associated with the request

This function takes a list communication requests created by non-blocking send or receive call ([tclmpi::isend](#) or [tclmpi::irecv](#)) and waits for the completion of all of them. In case of a send, it will merely wait until the matching communication is completed and any resources associated with the request will be released. If the request was generated by a non-blocking receive call, [tclmpi::wait](#) will hand the received data to the calling routine in its return value. The (optional) status argument would be the name of a variable in which the resulting status information will be stored in the form of an associative array. The associative array will have the entries MPI\_SOURCE (rank of sender), MPI\_TAG (tag of message), COUNT\_CHAR (size of message in bytes), COUNT\_INT (size of message in [tclmpi::int](#) units), COUNT\_DOUBLE (size of message in [tclmpi::double](#) units) and the results will be stored as lists with the information in the same order as the list of requests.

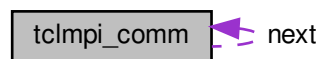
This call is implemented in Tcl as a wrapper around [tclmpi::wait](#)

## Chapter 9

# Class Documentation

### 9.1 tclmpi\_comm Struct Reference

Collaboration diagram for tclmpi\_comm:



#### Public Attributes

- const char \* [label](#)
- MPI\_Comm [comm](#)
- int [valid](#)
- [tclmpi\\_comm\\_t](#) \* [next](#)

#### 9.1.1 Detailed Description

Linked list entry to map MPI communicators to strings.

#### 9.1.2 Member Data Documentation

##### 9.1.2.1 comm

`MPI_Comm tclmpi_comm::comm`

MPI communicator corresponding of this entry

#### 9.1.2.2 label

```
const char* tclmpi_comm::label
```

String representing the communicator in Tcl

#### 9.1.2.3 next

```
tclmpi_comm_t* tclmpi_comm::next
```

Pointer to next element in linked list

#### 9.1.2.4 valid

```
int tclmpi_comm::valid
```

Non-zero if communicator is valid

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

- [\\_tclmpi.c](#)

## 9.2 tclmpi\_dblint Struct Reference

### Public Attributes

- double [d](#)
- int [i](#)

### 9.2.1 Detailed Description

Represent a double/integer pair

### 9.2.2 Member Data Documentation

#### 9.2.2.1 d

```
double tclmpi_dblint::d
```

double data value

### 9.2.2.2 i

```
int tclmpi_dblint::i
```

location data

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

- [\\_tclmpi.c](#)

## 9.3 tclmpi\_intint Struct Reference

### Public Attributes

- int [i1](#)
- int [i2](#)

### 9.3.1 Detailed Description

Represent an integer/integer pair

### 9.3.2 Member Data Documentation

#### 9.3.2.1 i1

```
int tclmpi_intint::i1
```

integer data value

#### 9.3.2.2 i2

```
int tclmpi_intint::i2
```

location data

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

- [\\_tclmpi.c](#)

## 9.4 tclmpi\_req Struct Reference

Collaboration diagram for tclmpi\_req:



### Public Attributes

- const char \* [label](#)
- void \* [data](#)
- int [len](#)
- int [type](#)
- int [source](#)
- int [tag](#)
- MPI\_Request \* [req](#)
- MPI\_Comm [comm](#)
- tclmpi\_req\_t \* [next](#)

### 9.4.1 Detailed Description

Linked list entry to map MPI requests to "tclmpi::req%d" strings.

### 9.4.2 Member Data Documentation

#### 9.4.2.1 comm

```
MPI_Comm tclmpi_req::comm
```

communicator for non-blocking receive

#### 9.4.2.2 data

```
void* tclmpi_req::data
```

pointer to send or receive data buffer



#### 9.4.2.3 label

```
const char* tclmpi_req::label
```

identifier of this request

#### 9.4.2.4 len

```
int tclmpi_req::len
```

size of data block

#### 9.4.2.5 next

```
tclmpi_req_t* tclmpi_req::next
```

pointer to next struct

#### 9.4.2.6 req

```
MPI_Request* tclmpi_req::req
```

pointer MPI request handle generated by MPI

#### 9.4.2.7 source

```
int tclmpi_req::source
```

source rank of non-blocking receive

#### 9.4.2.8 tag

```
int tclmpi_req::tag
```

tag selector of non-blocking receive

#### 9.4.2.9 type

```
int tclmpi_req::type
```

data type of send data

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

- [\\_tclmpi.c](#)



## Chapter 10

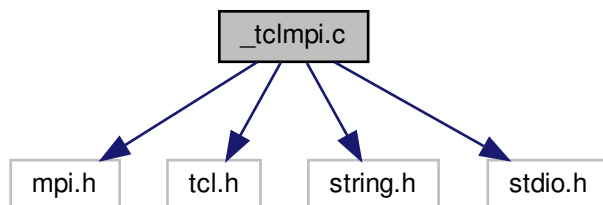
# File Documentation

### 10.1 `_tclmpi.c` File Reference

This file contains the C code with the Tcl MPI wrappers.

```
#include <mpi.h>
#include <tcl.h>
#include <string.h>
#include <stdio.h>
```

Include dependency graph for `_tclmpi.c`:



#### Classes

- struct [tclmpi\\_comm](#)
- struct [tclmpi\\_dblint](#)
- struct [tclmpi\\_intint](#)
- struct [tclmpi\\_req](#)

## Macros

- `#define MPI_VERSION 1`
- `#define TCLMPI_TOZERO -4`
- `#define TCLMPI_ABORT -3`
- `#define TCLMPI_ERROR -2`
- `#define TCLMPI_INVALID -1`
- `#define TCLMPI_NONE 0`
- `#define TCLMPI_AUTO 1`
- `#define TCLMPI_INT 2`
- `#define TCLMPI_INT_INT 3`
- `#define TCLMPI_DOUBLE 4`
- `#define TCLMPI_DOUBLE_INT 5`
- `#define TCLMPI_CONV_CHECK(type, in, out, assign)`

## Typedefs

- `typedef struct tclmpi_comm tclmpi_comm_t`
- `typedef struct tclmpi_dblint tclmpi_dblint_t`
- `typedef struct tclmpi_intint tclmpi_intint_t`
- `typedef struct tclmpi_req tclmpi_req_t`

## Functions

- `int TcLMPI_Init (ClientData nodata, Tcl_Interp *interp, int objc, Tcl_Obj *const objv[])`
- `int TcLMPI_Conv_set (ClientData nodata, Tcl_Interp *interp, int objc, Tcl_Obj *const objv[])`
- `int TcLMPI_Conv_get (ClientData nodata, Tcl_Interp *interp, int objc, Tcl_Obj *const objv[])`
- `int TcLMPI_Finalize (ClientData nodata, Tcl_Interp *interp, int objc, Tcl_Obj *const objv[])`
- `int TcLMPI_Abort (ClientData nodata, Tcl_Interp *interp, int objc, Tcl_Obj *const objv[])`
- `int TcLMPI_Comm_size (ClientData nodata, Tcl_Interp *interp, int objc, Tcl_Obj *const objv[])`
- `int TcLMPI_Comm_rank (ClientData nodata, Tcl_Interp *interp, int objc, Tcl_Obj *const objv[])`
- `int TcLMPI_Comm_split (ClientData nodata, Tcl_Interp *interp, int objc, Tcl_Obj *const objv[])`
- `int TcLMPI_Comm_free (ClientData nodata, Tcl_Interp *interp, int objc, Tcl_Obj *const objv[])`
- `int TcLMPI_Barrier (ClientData nodata, Tcl_Interp *interp, int objc, Tcl_Obj *const objv[])`
- `int TcLMPI_Bcast (ClientData nodata, Tcl_Interp *interp, int objc, Tcl_Obj *const objv[])`
- `int TcLMPI_Scatter (ClientData nodata, Tcl_Interp *interp, int objc, Tcl_Obj *const objv[])`
- `int TcLMPI_Allgather (ClientData nodata, Tcl_Interp *interp, int objc, Tcl_Obj *const objv[])`
- `int TcLMPI_Gather (ClientData nodata, Tcl_Interp *interp, int objc, Tcl_Obj *const objv[])`
- `int TcLMPI_Allreduce (ClientData nodata, Tcl_Interp *interp, int objc, Tcl_Obj *const objv[])`
- `int TcLMPI_Reduce (ClientData nodata, Tcl_Interp *interp, int objc, Tcl_Obj *const objv[])`
- `int TcLMPI_Send (ClientData nodata, Tcl_Interp *interp, int objc, Tcl_Obj *const objv[])`
- `int TcLMPI_Isend (ClientData nodata, Tcl_Interp *interp, int objc, Tcl_Obj *const objv[])`
- `int TcLMPI_Recv (ClientData nodata, Tcl_Interp *interp, int objc, Tcl_Obj *const objv[])`
- `int TcLMPI_Irecv (ClientData nodata, Tcl_Interp *interp, int objc, Tcl_Obj *const objv[])`
- `int TcLMPI_Probe (ClientData nodata, Tcl_Interp *interp, int objc, Tcl_Obj *const objv[])`
- `int TcLMPI_Iprobe (ClientData nodata, Tcl_Interp *interp, int objc, Tcl_Obj *const objv[])`
- `int TcLMPI_Wait (ClientData nodata, Tcl_Interp *interp, int objc, Tcl_Obj *const objv[])`
- `int _tclmpi_Init (Tcl_Interp *interp)`

### 10.1.1 Detailed Description

This file contains the C code with the Tcl MPI wrappers.

## 10.1.2 Macro Definition Documentation

### 10.1.2.1 MPI\_VERSION

```
#define MPI_VERSION 1
```

Define for backward compatibility with old MPI libraries. We need to be able to detect the API of MPI\_VERSION > 1 for clean error handling and making MPI errors catch-able.

### 10.1.2.2 TCLMPI\_ABORT

```
#define TCLMPI_ABORT -3
```

abort on problems

### 10.1.2.3 TCLMPI\_AUTO

```
#define TCLMPI_AUTO 1
```

the tcl native data type (string)

### 10.1.2.4 TCLMPI\_CONV\_CHECK

```
#define TCLMPI_CONV_CHECK(  
    type,  
    in,  
    out,  
    assign )
```

#### Value:

```
if (Tcl_Get ## type ## FromObj(interp,in,out) != TCL_OK) { \
    switch (tclmpi_conv_handler) { \
        case TCLMPI_TOZERO: \
            Tcl_ResetResult(interp); \
            assign=0; \
            break; \
        case TCLMPI_ABORT: \
            fprintf(stderr,"Error on data element %d: %s\n", \
                i, Tcl_GetStringResult(interp)); \
            MPI_Abort(comm,i); \
            break; \
        case TCLMPI_ERROR: \
            default: /* fallback */ \
                return TCL_ERROR; \
            break; \
    } \
}
```

Data conversion with with error handling

#### Parameters

<i>type</i>	Tcl data type for calling Tcl_Get<Type>FromObj()
<i>in</i>	pointer to input object for conversion
<i>out</i>	pointer to output storage for conversion
<i>assign</i>	target to assign a zero to for TCLMPI_TOZERO

This macro enables consistent handling of data conversions. It also queries the `tclmpi_conv_handler` variable to jump to the selected conversion error behavior. For `TCLMPI_ERROR` (the default) a Tcl error is raised and `TclMPI` returns to the calling function. For `TCLMPI_ABORT` and error message is written to `stderr` and parallel execution on the current communicator is terminated via `MPI_Abort()`. For `TCLMPI_TOZERO` the error is silently ignored and the data element handed in as assign parameter is set to zero.

#### 10.1.2.5 TCLMPI\_DOUBLE

```
#define TCLMPI_DOUBLE 4
```

floating point data type

#### 10.1.2.6 TCLMPI\_DOUBLE\_INT

```
#define TCLMPI_DOUBLE_INT 5
```

data type for double/integer pair

#### 10.1.2.7 TCLMPI\_ERROR

```
#define TCLMPI_ERROR -2
```

flag problems as Tcl errors

#### 10.1.2.8 TCLMPI\_INT

```
#define TCLMPI_INT 2
```

data type for integers

#### 10.1.2.9 TCLMPI\_INT\_INT

```
#define TCLMPI_INT_INT 3
```

data type for pairs of integers

#### 10.1.2.10 TCLMPI\_INVALID

```
#define TCLMPI_INVALID -1
```

not ready to handle data

#### 10.1.2.11 TCLMPI\_NONE

```
#define TCLMPI_NONE 0
```

no data type assigned

### 10.1.2.12 TCLMPI\_TOZERO

```
#define TCLMPI_TOZERO -4
```

convert problematic data items to zero

## 10.1.3 Typedef Documentation

### 10.1.3.1 tclmpi\_comm\_t

```
typedef struct tclmpi_comm tclmpi_comm_t
```

Linked list entry type for managing MPI communicators

### 10.1.3.2 tclmpi\_dblint\_t

```
typedef struct tclmpi_dblint tclmpi_dblint_t
```

Data type for maxloc/minloc reductions with a double and an integer

### 10.1.3.3 tclmpi\_intint\_t

```
typedef struct tclmpi_intint tclmpi_intint_t
```

Data type for maxloc/minloc reductions with two integers

### 10.1.3.4 tclmpi\_req\_t

```
typedef struct tclmpi_req tclmpi_req_t
```

Linked list entry type for managing MPI requests

## 10.1.4 Function Documentation

### 10.1.4.1 \_tclmpi\_Init()

```
int _tclmpi_Init (  
    Tcl_Interp * interp )
```

register the package as a plugin with the Tcl interpreter

**Parameters**

<i>interp</i>	current Tcl interpreter
---------------	-------------------------

**Returns**

TCL\_OK or TCL\_ERROR

This function sets up the plugin to register the various MPI wrappers in this package with the Tcl interpreter.

Depending on the USE\_TCL\_STUBS define being active or not, this is done using the native dynamic loader interface or the Tcl stubs interface, which would allow to load the plugin into static executables and plugins from different Tcl versions.

In addition the linked list for translating MPI communicators is initialized for the predefined communicators [tclmpi::comm\\_world](#), [tclmpi::comm\\_self](#), and [tclmpi::comm\\_null](#) and its corresponding MPI counterparts.

**10.1.4.2 TclMPI\_Abort()**

```
int TclMPI_Abort (
    ClientData nodata,
    Tcl_Interp * interp,
    int objc,
    Tcl_Obj *const objv[] )
```

wrapper for MPI\_Abort()

**Parameters**

<i>nodata</i>	ignored
<i>interp</i>	current Tcl interpreter
<i>objc</i>	number of argument objects
<i>objv</i>	list of argument object

**Returns**

TCL\_OK or TCL\_ERROR

This function translates the Tcl string representing a communicator into the corresponding MPI communicator and then calls MPI\_Abort().

**10.1.4.3 TclMPI\_Allgather()**

```
int TclMPI_Allgather (
    ClientData nodata,
    Tcl_Interp * interp,
    int objc,
    Tcl_Obj *const objv[] )
```

wrapper for MPI\_Allgather()



## Parameters

<i>nodata</i>	ignored
<i>interp</i>	current Tcl interpreter
<i>objc</i>	number of argument objects
<i>objv</i>	list of argument object

## Returns

TCL\_OK or TCL\_ERROR

This function implements a gather operation that collects data for TcIMPI. This operation does not accept the `tclmpi::auto` data type, also support for types outside of `tclmpi::int` and `tclmpi::double` is incomplete. The length of the data is inferred from the data object passed to this function and thus a 'count' argument is not needed. The number of data items has to be the same on all processes on the communicator.

The result is converted back into Tcl objects and passed up as result value to the calling Tcl code on all processors. If the MPI call failed, an MPI error message is passed up as result instead.

## 10.1.4.4 TcIMPI\_Allreduce()

```
int TcIMPI_Allreduce (
    ClientData nodata,
    Tcl_Interp * interp,
    int objc,
    Tcl_Obj *const objv[] )
```

wrapper for MPI\_Allreduce()

## Parameters

<i>nodata</i>	ignored
<i>interp</i>	current Tcl interpreter
<i>objc</i>	number of argument objects
<i>objv</i>	list of argument object

## Returns

TCL\_OK or TCL\_ERROR

This function implements a reduction plus broadcast function for TcIMPI. This operation does not accept the `tclmpi::auto` data type, also support for types outside of `tclmpi::int` and `tclmpi::double` is incomplete. The length of the data is inferred from the data object passed to this function and thus a 'count' argument is not needed.

The result is converted back into Tcl objects and passed up as result value to the calling Tcl code. If the MPI call failed, an MPI error message is passed up as result instead.

## 10.1.4.5 TcIMPI\_Barrier()

```
int TcIMPI_Barrier (
    ClientData nodata,
```

```
Tcl_Interp * interp,
int objc,
Tcl_Obj *const objv[] )
```

wrapper for MPI\_Barrier()

#### Parameters

<i>nodata</i>	ignored
<i>interp</i>	current Tcl interpreter
<i>objc</i>	number of argument objects
<i>objv</i>	list of argument object

#### Returns

TCL\_OK or TCL\_ERROR

This function translates the Tcl string representing a communicator into the corresponding MPI communicator and then calls MPI\_Barrier(). If the MPI call failed, an MPI error message is passed up as result.

#### 10.1.4.6 TclMPI\_Bcast()

```
int TclMPI_Bcast (
    ClientData nodata,
    Tcl_Interp * interp,
    int objc,
    Tcl_Obj *const objv[] )
```

wrapper for MPI\_Bcast()

#### Parameters

<i>nodata</i>	ignored
<i>interp</i>	current Tcl interpreter
<i>objc</i>	number of argument objects
<i>objv</i>	list of argument object

#### Returns

TCL\_OK or TCL\_ERROR

This function implements a broadcast function for TclMPI. Unlike in the C bindings, the length of the data is inferred from the data object passed to this function and thus a 'count' argument is not needed. Only a limited number of data types are currently supported, since Tcl has a limited number of "native" data types. The [tclmpi::auto](#) data type transfers the internal string representation of an object, while the other data types convert data to native data types as needed, with all non-representable data translated into either 0 or 0.0. In all cases, two broadcasts are needed. The first to transmit the amount of data being sent so that a suitable receive buffer can be set up.

The result of the broadcast is converted back into Tcl objects and passed up as result value to the calling Tcl code. If the MPI call failed, an MPI error message is passed up as result instead.

#### 10.1.4.7 TcIMPI\_Comm\_free()

```
int TcIMPI_Comm_free (
    ClientData nodata,
    Tcl_Interp * interp,
    int objc,
    Tcl_Obj *const objv[] )
```

wrapper for MPI\_Comm\_free()

##### Parameters

<i>nodata</i>	ignored
<i>interp</i>	current Tcl interpreter
<i>objc</i>	number of argument objects
<i>objv</i>	list of argument object

##### Returns

TCL\_OK or TCL\_ERROR

This function deletes a defined MPI communicator and removes its Tcl representation from the local translation tables.

#### 10.1.4.8 TcIMPI\_Comm\_rank()

```
int TcIMPI_Comm_rank (
    ClientData nodata,
    Tcl_Interp * interp,
    int objc,
    Tcl_Obj *const objv[] )
```

wrapper for MPI\_Comm\_rank()

##### Parameters

<i>nodata</i>	ignored
<i>interp</i>	current Tcl interpreter
<i>objc</i>	number of argument objects
<i>objv</i>	list of argument object

##### Returns

TCL\_OK or TCL\_ERROR

This function translates the Tcl string representing a communicator into the corresponding MPI communicator and then calls MPI\_Comm\_rank() on it. The resulting number is passed to Tcl as result or the MPI error message is passed up similarly.

#### 10.1.4.9 TclMPI\_Comm\_size()

```
int TclMPI_Comm_size (
    ClientData nodata,
    Tcl_Interp * interp,
    int objc,
    Tcl_Obj *const objv[] )
```

wrapper for MPI\_Comm\_size()

##### Parameters

<i>nodata</i>	ignored
<i>interp</i>	current Tcl interpreter
<i>objc</i>	number of argument objects
<i>objv</i>	list of argument object

##### Returns

TCL\_OK or TCL\_ERROR

This function translates the Tcl string representing a communicator into the corresponding MPI communicator and then calls MPI\_Comm\_size() on it. The resulting number is passed to Tcl as result or the MPI error message is passed up similarly.

#### 10.1.4.10 TclMPI\_Comm\_split()

```
int TclMPI_Comm_split (
    ClientData nodata,
    Tcl_Interp * interp,
    int objc,
    Tcl_Obj *const objv[] )
```

wrapper for MPI\_Comm\_split()

##### Parameters

<i>nodata</i>	ignored
<i>interp</i>	current Tcl interpreter
<i>objc</i>	number of argument objects
<i>objv</i>	list of argument object

##### Returns

TCL\_OK or TCL\_ERROR

This function translates the Tcl string representing a communicator into the corresponding MPI communicator also checks and converts the values for 'color' and 'key' and then calls MPI\_Comm\_split(). The resulting communicator is added to the internal communicator map linked list and its string representation is passed to Tcl as result. If the MPI call failed, the MPI error message is passed up similarly.

**10.1.4.11 TcIMPI\_Conv\_get()**

```
int TcIMPI_Conv_get (
    ClientData nodata,
    Tcl_Interp * interp,
    int objc,
    Tcl_Obj *const objv[] )
```

Get error handler string for data conversions in TcIMPI

**Parameters**

<i>nodata</i>	ignored
<i>interp</i>	current Tcl interpreter
<i>objc</i>	number of argument objects
<i>objv</i>	list of argument object

**Returns**

TCL\_OK

This function returns which error handler is currently active for data conversions in TcIMPI. For details see [TcIMPI\\_Conv\\_set\(\)](#).

There is no equivalent MPI function for this, since there are no data conversions in C or C++.

**10.1.4.12 TcIMPI\_Conv\_set()**

```
int TcIMPI_Conv_set (
    ClientData nodata,
    Tcl_Interp * interp,
    int objc,
    Tcl_Obj *const objv[] )
```

Set error handler for data conversions in TcIMPI

**Parameters**

<i>nodata</i>	ignored
<i>interp</i>	current Tcl interpreter
<i>objc</i>	number of argument objects
<i>objv</i>	list of argument object

**Returns**

TCL\_OK or TCL\_ERROR

This function sets what action TcIMPI should take if a conversion of a data element to the requested integer or double data type fails. There are currently three handlers implemented: [TCLMPI\\_ERROR](#), [TCLMPI\\_ABORT](#), and [TCLMPI\\_TOZERO](#).

For [TCLMPI\\_ERROR](#) a Tcl error is raised and TclMPI returns to the calling function. For [TCLMPI\\_ABORT](#) an error message is written to the error output and parallel execution on the current communicator is terminated via `MPI_Abort()`. For [TCLMPI\\_TOZERO](#) the error is silently ignored and the data element set to zero.

There is no equivalent MPI function for this, since there are no data conversions in C or C++.

#### 10.1.4.13 TclMPI\_Finalize()

```
int TclMPI_Finalize (
    ClientData nodaata,
    Tcl_Interp * interp,
    int objc,
    Tcl_Obj *const objv[] )
```

wrapper for `MPI_Finalize()`

##### Parameters

<i>nodaata</i>	ignored
<i>interp</i>	current Tcl interpreter
<i>objc</i>	number of argument objects
<i>objv</i>	list of argument object

##### Returns

TCL\_OK or TCL\_ERROR

This function does a little more than just calling `MPI_Finalize()`. It also tries to detect whether `MPI_Init()` or `MPI_Finalize()` have been called before (from Tcl) and then creates a (catchable) Tcl error instead of an (uncatchable) MPI error.

#### 10.1.4.14 TclMPI\_Gather()

```
int TclMPI_Gather (
    ClientData nodaata,
    Tcl_Interp * interp,
    int objc,
    Tcl_Obj *const objv[] )
```

wrapper for `MPI_Gather()`

##### Parameters

<i>nodaata</i>	ignored
<i>interp</i>	current Tcl interpreter
<i>objc</i>	number of argument objects
<i>objv</i>	list of argument object

**Returns**

TCL\_OK or TCL\_ERROR

This function implements a gather operation that collects data for TcMPI. This operation does not accept the `tclmpi::auto` data type, also support for types outside of `tclmpi::int` and `tclmpi::double` is incomplete. The length of the data is inferred from the data object passed to this function and thus a 'count' argument is not needed. The number of data items has to be the same on all processes on the communicator.

The result is converted back into Tcl objects and passed up as result value to the calling Tcl code on the root processor. If the MPI call failed, an MPI error message is passed up as result instead.

**10.1.4.15 TcMPI\_Init()**

```
int TcMPI_Init (
    ClientData nodata,
    Tcl_Interp * interp,
    int objc,
    Tcl_Obj *const objv[] )
```

wrapper for MPI\_Init()

**Parameters**

<i>nodata</i>	ignored
<i>interp</i>	current Tcl interpreter
<i>objc</i>	number of argument objects
<i>objv</i>	list of argument object

**Returns**

TCL\_OK or TCL\_ERROR

This function does a little more work than just calling MPI\_Init(). First of it tries to detect whether MPI\_Init() has been called before (from Tcl) and then creates a (catchable) Tcl error instead of an (uncatchable) MPI error. It will also try to pass the argument vector to the script from the Tcl generated 'argv' array to the underlying MPI\_Init() call and reset argv as needed.

**10.1.4.16 TcMPI\_Iprobe()**

```
int TcMPI_Iprobe (
    ClientData nodata,
    Tcl_Interp * interp,
    int objc,
    Tcl_Obj *const objv[] )
```

wrapper for MPI\_Iprobe()

**Parameters**

<i>nodata</i>	ignored
<i>interp</i>	current Tcl interpreter
<i>objc</i>	number of argument objects
<i>objv</i>	list of argument object

**Returns**

TCL\_OK or TCL\_ERROR

This function implements a non-blocking probe operation for TcIMPI. Argument flags for source, tag, and communicator are translated into their native MPI equivalents and then MPI\_Iprobe called.

Similar to MPI\_Probe, generating a status object to inspect the pending receive is optional. If desired, the argument is taken as a variable name which will then be generated as associative array with several entries similar to what MPI\_Status contains. Those are source, tag, error status and count, however this is directly provided as multiple entries translated to char, int and double data types (COUNT\_CHAR, COUNT\_INT, COUNT\_DOUBLE).

The status flag in MPI\_Iprobe that returns true if a request is pending will be passed to the calling routine as Tcl result.

**10.1.4.17 TcIMPI\_Irecv()**

```
int TcIMPI_Irecv (
    ClientData nodata,
    Tcl_Interp * interp,
    int objc,
    Tcl_Obj *const objv[] )
```

wrapper for MPI\_Irecv()

**Parameters**

<i>nodata</i>	ignored
<i>interp</i>	current Tcl interpreter
<i>objc</i>	number of argument objects
<i>objv</i>	list of argument object

**Returns**

TCL\_OK or TCL\_ERROR

This function implements a non-blocking receive operation for TcIMPI. Since the length of the data object is supposed to be automatically adjusted to the amount of data being sent, this function needs to be more complex than just a simple wrapper around the corresponding MPI C bindings. It will first call tcimpi\_add\_req to generate a new entry to the list of registered MPI requests. It will then call MPI\_Iprobe to see if a matching send is already in progress and thus the necessary amount of storage required can be inferred from the MPI\_Status object that is populated by MPI\_Iprobe. If yes, a temporary receive buffer is allocated and the non-blocking receive is posted and all information is transferred to the tcimpi\_req\_t object. If not, only the arguments of the receive call are registered in the request object for later use. The command will pass the Tcl string that represents the generated MPI request to the Tcl interpreter as return value. If the MPI call failed, an MPI error message is passed up as result instead and a Tcl error is indicated.

**10.1.4.18 TcIMPI\_Isend()**

```
int TcIMPI_Isend (
    ClientData nodata,
    Tcl_Interp * interp,
```



```
int objc,  
Tcl_Obj *const objv[] )
```

wrapper for MPI\_Isend()

**Parameters**

<i>nodata</i>	ignored
<i>interp</i>	current Tcl interpreter
<i>objc</i>	number of argument objects
<i>objv</i>	list of argument object

**Returns**

TCL\_OK or TCL\_ERROR

This function implements a non-blocking send operation for TcIMPI. The length of the data is inferred from the data object passed to this function and thus a 'count' argument is not needed. Unlike for the blocking TcIMPI\_Send, in the case of `tclmpi::auto` as data a copy has to be made since the string representation of the send data might be invalidated during the send. The command generates a new `tclmpi_req_t` communication request via `tclmpi_addreq` and the pointers to the data buffer and the MPI\_Request info generated by MPI\_Isend is stored in this request list entry for later perusal, see TcIMPI\_Wait. The generated string label representing this request will be passed on to the calling program as Tcl result. If the MPI call failed, an MPI error message is passed up as result instead and a Tcl error is indicated.

**10.1.4.19 TcIMPI\_Probe()**

```
int TcIMPI_Probe (
    ClientData nodata,
    Tcl_Interp * interp,
    int objc,
    Tcl_Obj *const objv[] )
```

wrapper for MPI\_Probe()

**Parameters**

<i>nodata</i>	ignored
<i>interp</i>	current Tcl interpreter
<i>objc</i>	number of argument objects
<i>objv</i>	list of argument object

**Returns**

TCL\_OK or TCL\_ERROR

This function implements a blocking probe operation for TcIMPI. Argument flags for source, tag, and communicator are translated into their native MPI equivalents and then MPI\_Probe called.

Similar to MPI\_Probe, generating a status object to inspect the pending receive is optional. If desired, the argument is taken as a variable name which will then be generated as associative array with several entries similar to what MPI\_Status contains. Those are source, tag, error status and count, however this is directly provided as multiple entries translated to char, int and double data types (COUNT\_CHAR, COUNT\_INT, COUNT\_DOUBLE).

#### 10.1.4.20 TcIMPI\_Recv()

```
int TcIMPI_Recv (
    ClientData nodata,
    Tcl_Interp * interp,
    int objc,
    Tcl_Obj *const objv[] )
```

wrapper for MPI\_Recv()

##### Parameters

<i>nodata</i>	ignored
<i>interp</i>	current Tcl interpreter
<i>objc</i>	number of argument objects
<i>objv</i>	list of argument object

##### Returns

TCL\_OK or TCL\_ERROR

This function implements a blocking receive operation for TcIMPI. Since the length of the data object is supposed to be automatically adjusted to the amount of data being sent, this function will first call MPI\_Probe to identify the amount of storage needed from the MPI\_Status object that is populated by MPI\_Probe. Then a temporary receive buffer is allocated and then converted back to Tcl objects according to the data type passed to the receive command. Due to this deviation from the MPI C bindings a 'count' argument is not needed. This command returns the received data to the calling procedure. If the MPI call failed, an MPI error message is passed up as result instead and a Tcl error is indicated.

#### 10.1.4.21 TcIMPI\_Reduce()

```
int TcIMPI_Reduce (
    ClientData nodata,
    Tcl_Interp * interp,
    int objc,
    Tcl_Obj *const objv[] )
```

wrapper for MPI\_Reduce()

##### Parameters

<i>nodata</i>	ignored
<i>interp</i>	current Tcl interpreter
<i>objc</i>	number of argument objects
<i>objv</i>	list of argument object

**Returns**

TCL\_OK or TCL\_ERROR

This function implements a reduction function for TclMPI. This operation does not accept the [tclmpi::auto](#) data type, also support for types outside of [tclmpi::int](#) and [tclmpi::double](#) is incomplete. The length of the data is inferred from the data object passed to this function and thus a 'count' argument is not needed.

The result is collected on the process with rank root and converted back into Tcl objects and passed up as result value to the calling Tcl code. If the MPI call failed an MPI error message is passed up as result instead.

**10.1.4.22 TclMPI\_Scatter()**

```
int TclMPI_Scatter (
    ClientData nodata,
    Tcl_Interp * interp,
    int objc,
    Tcl_Obj *const objv[] )
```

wrapper for MPI\_Scatter()

**Parameters**

<i>nodata</i>	ignored
<i>interp</i>	current Tcl interpreter
<i>objc</i>	number of argument objects
<i>objv</i>	list of argument object

**Returns**

TCL\_OK or TCL\_ERROR

This function implements a scatter operation that distributes data for TclMPI. This operation does not accept the [tclmpi::auto](#) data type, also support for types outside of [tclmpi::int](#) and [tclmpi::double](#) is incomplete. The length of the data is inferred from the data object passed to this function and thus a 'count' argument is not needed. The number of data items has to be divisible by the number of processes on the communicator.

The result is converted back into Tcl objects and passed up as result value to the calling Tcl code. If the MPI call failed an MPI error message is passed up as result instead.

**10.1.4.23 TclMPI\_Send()**

```
int TclMPI_Send (
    ClientData nodata,
    Tcl_Interp * interp,
    int objc,
    Tcl_Obj *const objv[] )
```

wrapper for MPI\_Send()

## Parameters

<i>nodata</i>	ignored
<i>interp</i>	current Tcl interpreter
<i>objc</i>	number of argument objects
<i>objv</i>	list of argument object

## Returns

TCL\_OK or TCL\_ERROR

This function implements a blocking send operation for TclMPI. The length of the data is inferred from the data object passed to this function and thus a 'count' argument is not needed. In the case of `tclmpi::auto`, the string representation of the send data is directly passed to `MPI_Send()` otherwise a copy is made and data converted.

If the MPI call failed, an MPI error message is passed up as result instead and a Tcl error is indicated, otherwise nothing is returned.

## 10.1.4.24 TclMPI\_Wait()

```
int TclMPI_Wait (
    ClientData nodata,
    Tcl_Interp * interp,
    int objc,
    Tcl_Obj *const objv[] )
```

wrapper for MPI\_Wait()

## Parameters

<i>nodata</i>	ignored
<i>interp</i>	current Tcl interpreter
<i>objc</i>	number of argument objects
<i>objv</i>	list of argument object

## Returns

TCL\_OK or TCL\_ERROR

This function implements a wrapper around `MPI_Wait` for TclMPI. Due to the design decisions in TclMPI, it works a bit different than `MPI_Wait`, particularly for non-blocking receive requests. As explained in the `TclMPI_Irecv` documentation, the corresponding `MPI_Irecv` may not yet have been posted, so we have to first inspect the `tclmpi_req_t` object, if the receive still needs to be posted. If yes, then we need to do about the same procedure as for a blocking receive, i.e. call `MPI_Probe` to determine the size of the receive buffer, allocate that buffer and then post a blocking receive. If no, we call `MPI_Wait` to wait until the non-blocking receive is completed. In both cases, the result needed to be converted to Tcl objects and passed to the calling procedure as Tcl return values. Then the receive buffers can be deleted and the `tclmpi_req_t` entry removed from it translation table.

For non-blocking send requests, `MPI_Wait` is called and after completion the send buffer freed and the `tclmpi_req_t` data released. The MPI spec allows to call `MPI_Wait` on non-existing MPI\_Requests and just return immediately. This is handled directly without calling `MPI_Wait`, since we cache all generated MPI requests.

## 10.2 harness.tcl File Reference

This file contains the TclMPI test harness script code.

### 10.2.1 Detailed Description

This file contains the TclMPI test harness script code.

This namespace contains several Tcl procedures that are used to conduct unit tests on the TclMPI package. For simplicity paths are hardcoded, so that this file must not be moved around and stay in the same directory as the individual tests, which in turn have to be in subdirectory of the directory where the TclMPI shared object and/or the tclmpish extended Tcl shell reside.

## 10.3 tclmpi.tcl File Reference

This file contains the Tcl script parts of the tclmpi namespace and the embedded documentation of the Tcl API of TclMPI.

### 10.3.1 Detailed Description

This file contains the Tcl script parts of the tclmpi namespace and the embedded documentation of the Tcl API of TclMPI.

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