Error Handling for Libraries

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Goals

- In general, error messages should
  - detailed
  - specific to the instance that caused the error
  - uniform in language
- In software libraries
  - Errors should be indicated by an error return or exception
  - The error return value should not require special treatment
    - for example, the user should be able to ignore it and not have to free it
- Messages and Codes
  - Documentation can provide far more detailed information about user and system errors than is appropriate for an error message
- Don't forget Internationalization
  - Unicode
- Most of all, it must encourage use
  - The perfect system is useless if programmers won't use it

Existing Tools for Error Messages

- National Language Support (NLS) tools
  - Good: Works with a message catalog (helps unify messages)
  - Widely available (part of Xopen/Unix)
  - Bad: Messages are all generic ("syntax error" not "variable foo is undeclared")
  - Messages identified by a number in a routine call
- Message Format (msgfmt) tools
  - Good: message ids are text, not integers (see man -3i gettext on Solaris)
  - Bad: Messages are all generic
  - Bad: Ids not usable in libraries
- In both cases, message can contain formatting instructions, but then can't be used directly with an id (where is the data saved?)

Error Handling in MPI

- Errors in MPI cause the MPI implementation to return an error *code* which is an integer.
- Each error code belongs to an error *class*. Example classes are MPI_ERR_ARG and MPI_ERR_RANK.
- An error code may contain additional information beyond the class
- The routine

```
MPI_ERROR_STRING( int code, char *message,
                  int *msglen )
```

converts a *code* into a character message. The routine

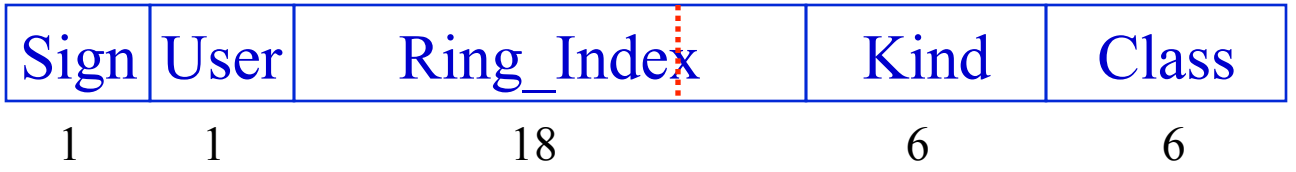
```
MPI_ERROR_CLASS( int code, int *class )
```

converts a code to a class.

- Errors invoke an error handler
  - MPI_ERRORS_ARE_FATAL
  - MPI_ERRORS_RETURN

Error Handling in MPICH

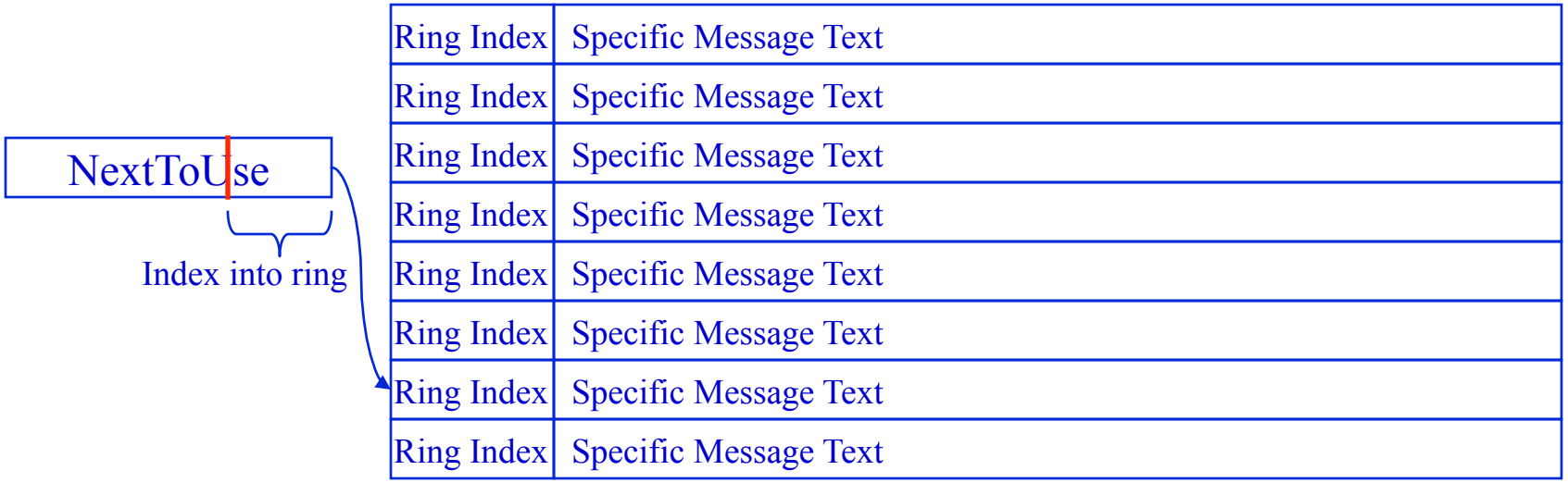
- An error code in MPICH has the following parts:



- Kind specifies a more specific, generic message within a class
- Ring_Index identifies a particular buffer containing a message that is specific to the instance that caused the error
- User is used to indicate a user-defined error class or code (part of MPI-2)
- Sign is zero to keep error codes non-negative

The Error Message Ring

- Instance specific messages are placed in a ring



- Ring_Index is larger than the actual ring
  - Just use low bits
- Check full Ring_Index when accessing message
  - if does not match value in error code, message has been lost
    - Use generic message in that case

Placing Messages in the Source

- MPIR_Err_setmsg(class, code, routine_name, generic_string, instance_string, arguments, …)
- For example
  - mpi_errno = MPIR_Err_setmsg(MPI_ERR_TOPOLOGY,
    MPIR_ERR_TOPO_TOO_LARGE, myname,
    "Topology size is larger than size of communicator",
    "Topology size %d is greater than communicator size %d",
    num_ranks, size);
- Activating the appropriate error handler
  - return MPIR_ERROR(comm_ptr, mpi_errno, myname);

Creating the Message Catalogs

- GetMsgCat
  - Perl Script matches MPIR_Err_setmsg
    - Handles multiline uses
    - Generates
      - NLS style message catalog (for gencat)
      - mpierrstrings.h file containing all message strings
        - » ensures that error messages can be generated even if there is a problem with the NLS system
        - » No “NLS catalog not found” error messages ☺

Common Messages

- Some messages used in many routines, e.g.,
  - rank -3 is not a valid rank
  - variable buf is null
- These should have the exact same text everywhere
- Use
  - same text in all uses of MPIR_Err_setmsg
  - use (char *)0 to indicate default
    - default version of messages can be placed in a common file

Finding Mistakes

- Look for printf, puts and generate list
- Allow PRINTF, PUTS, etc. for non-user messages
  - Internal debugging messages
  - Language-independent output
- Definition of PRINTF, PUTS can be different from just printf, puts
  - Programs with no stdout/stderr (Windows)
  - Output in parallel applications

Further Improvements

- Make it easier to insert a new error message
  - Automatically detect and insert new error kinds
- Improve “Messages and Codes”
  - Automatically generate HTML etc.
  - Update more detailed descriptions