User Level Failure Mitigation Reading

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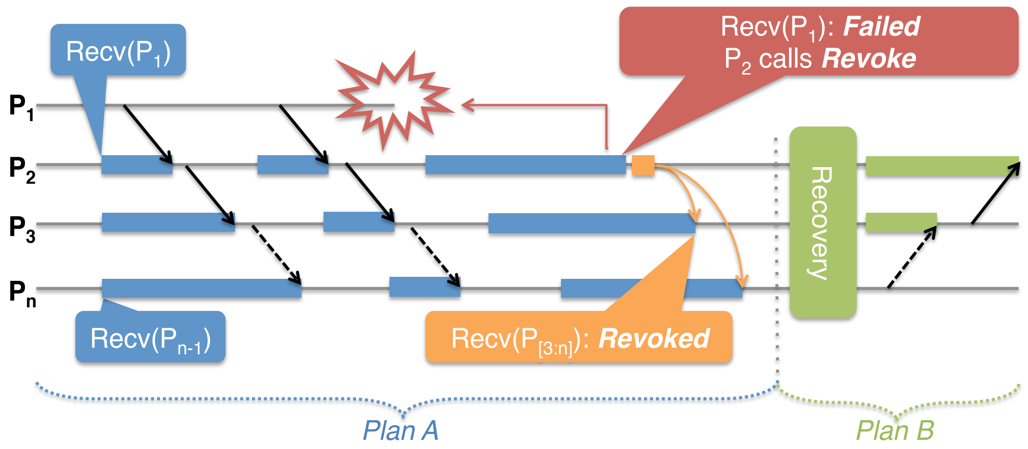
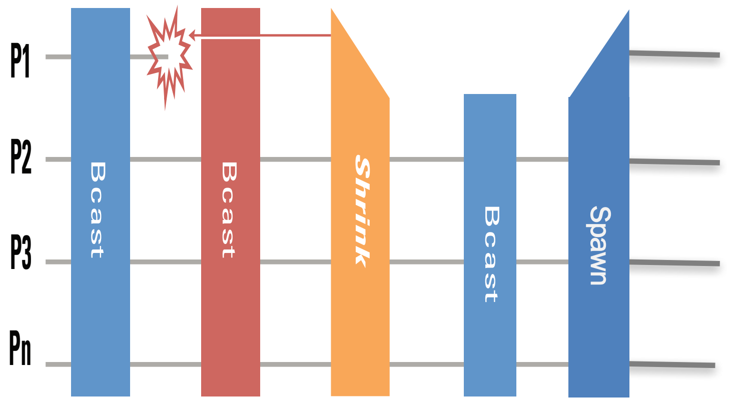
User Level Failure Mitigation: Specification Status

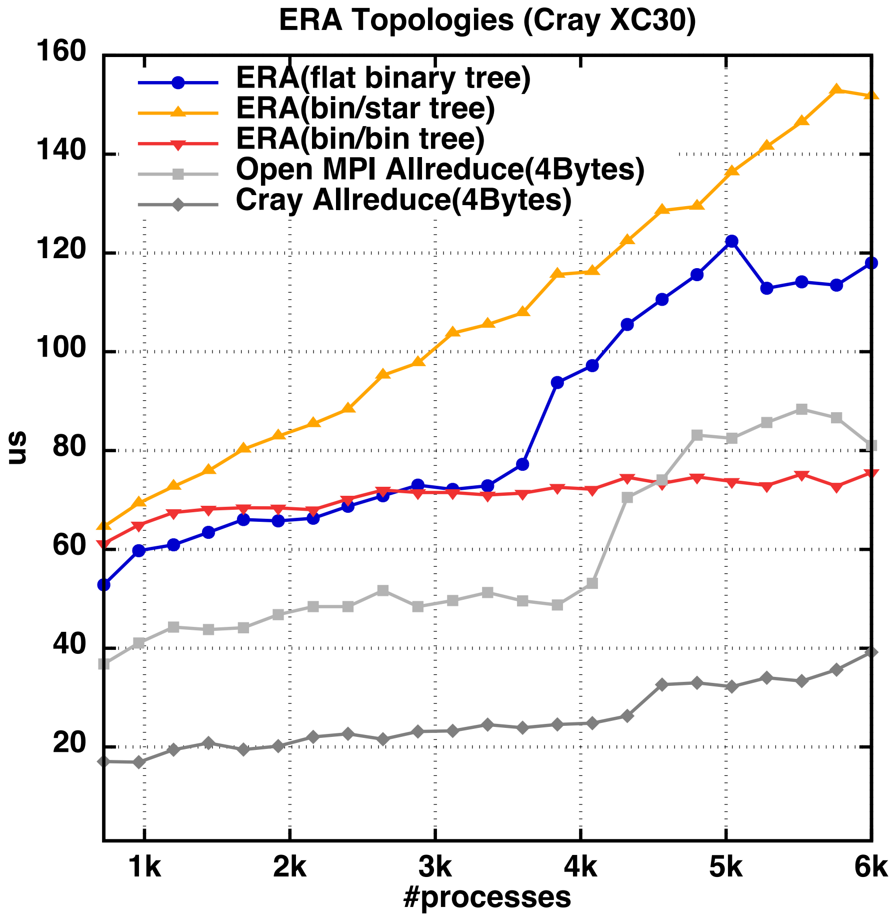




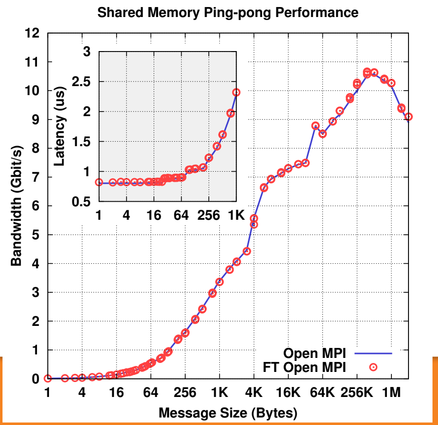
- Adds 3 error codes and 5 functions to manage process crash
  - **Error codes:** interrupt operations that may block due to process crash
  - **MPI_COMM_FAILURE_ACK/GET_ACKED:** continued operation with ANY-SOURCE RECV and observation known failures
  - **MPI_COMM_REVOKE** lets applications interrupt operations on a communicator
  - **MPI_COMM_AGREE:** synchronize failure knowledge in the application
  - **MPI_COMM_SHRINK:** create a communicator excluding failed processes
- Similar WIN/FILE_REVOKE

User Level Failure Mitigation: Implementations

- Implementation available in Open MPI and MPICH
  - Open MPI implementation updated in-sync with Open MPI 2.x
  - Scalable fault tolerant algorithms demonstrated in practice (SC'14, EuroMPI'15, SC'15, SC'16)



Fault Tolerant Agreement costs approximately 2x Allreduce



Point to point performance unchanged With FT enabled

User Level Failure Mitigation: User Adoption

Fenix Framework

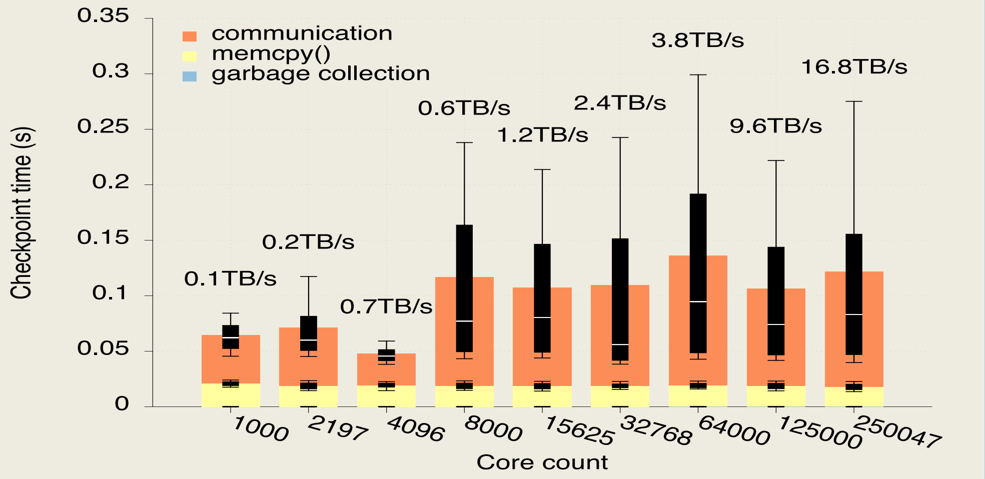


Fig. 3. Checkpoint time for different core counts (8.6 MB/core). The numbers above each test show the aggregated bandwidth (the total checkpoint size over the average checkpoint time).

MapReduce

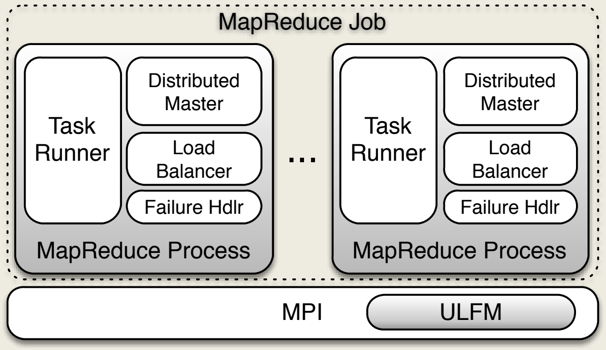
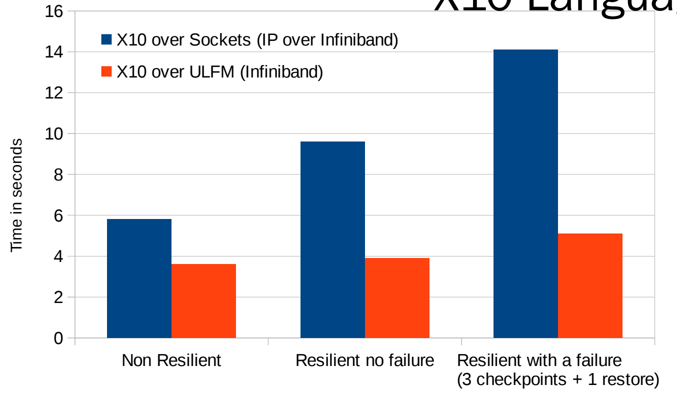


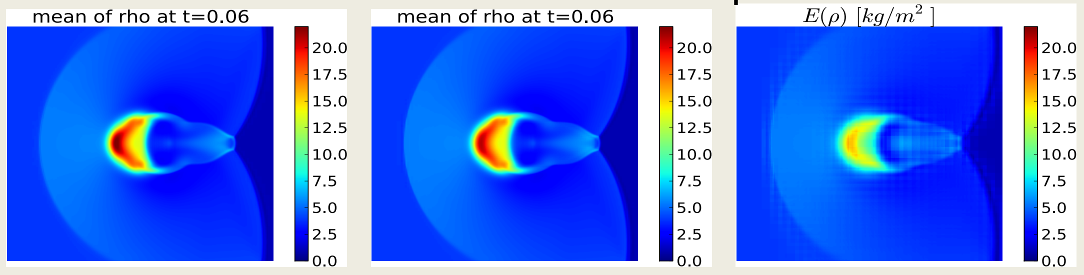
Figure 2: The architecture of FT-MRMPI.

X10 Language



The performance improvement due to using ULFM v1.0 for running the LULESH proxy application [3] (a shock hydrodynamics stencil based simulation) running on 64 processes on 16 nodes with

Domain Decomposition PDE



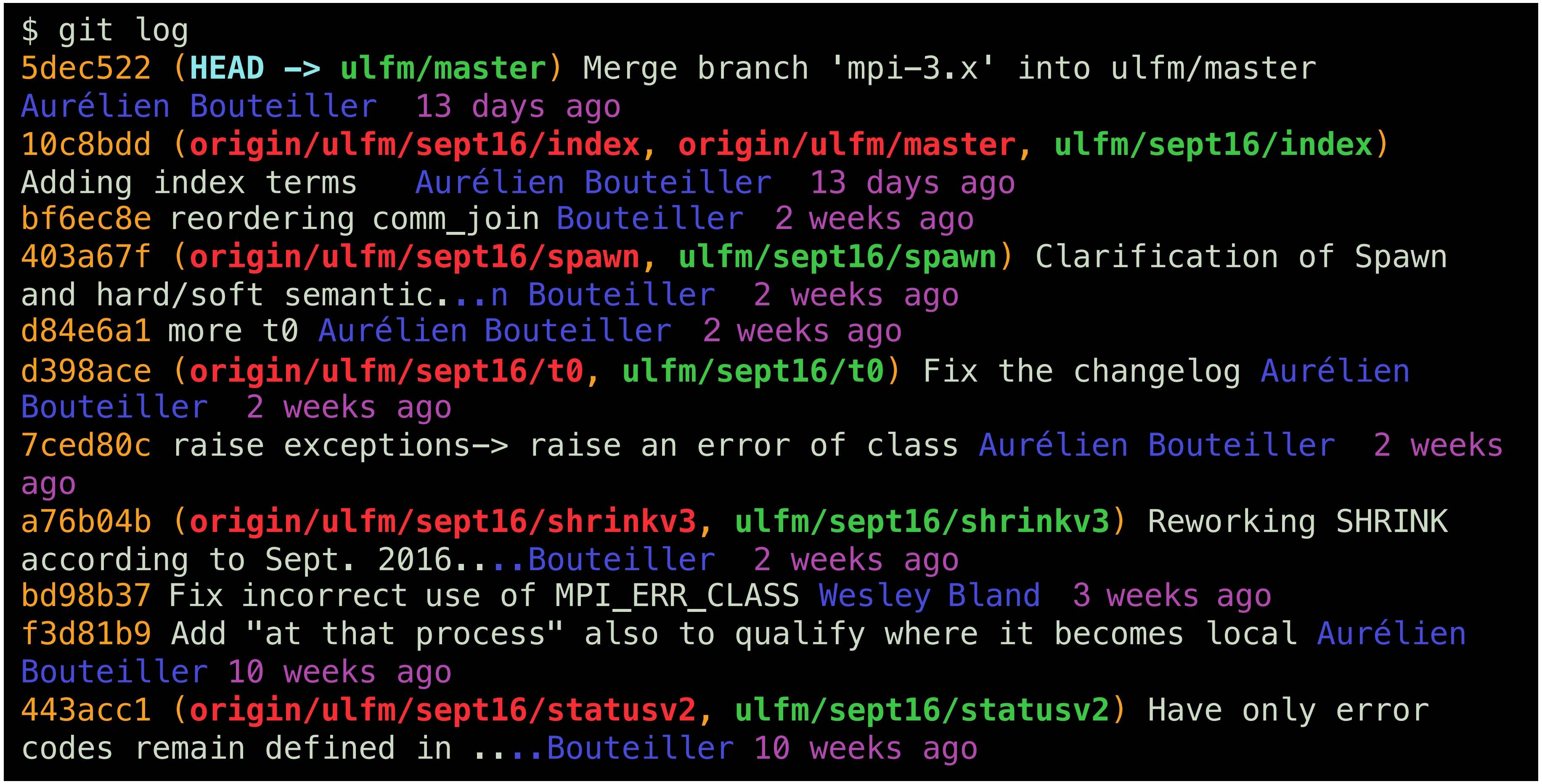
(a) failure-free (b) few failures (c) many failures

Figure 5. Results of the FT-MLMC implementation for three different failure scenarios.

- Fortran CoArrays "failed images" uses ULFM-RMA to support Fortran TS 18508

And many more...

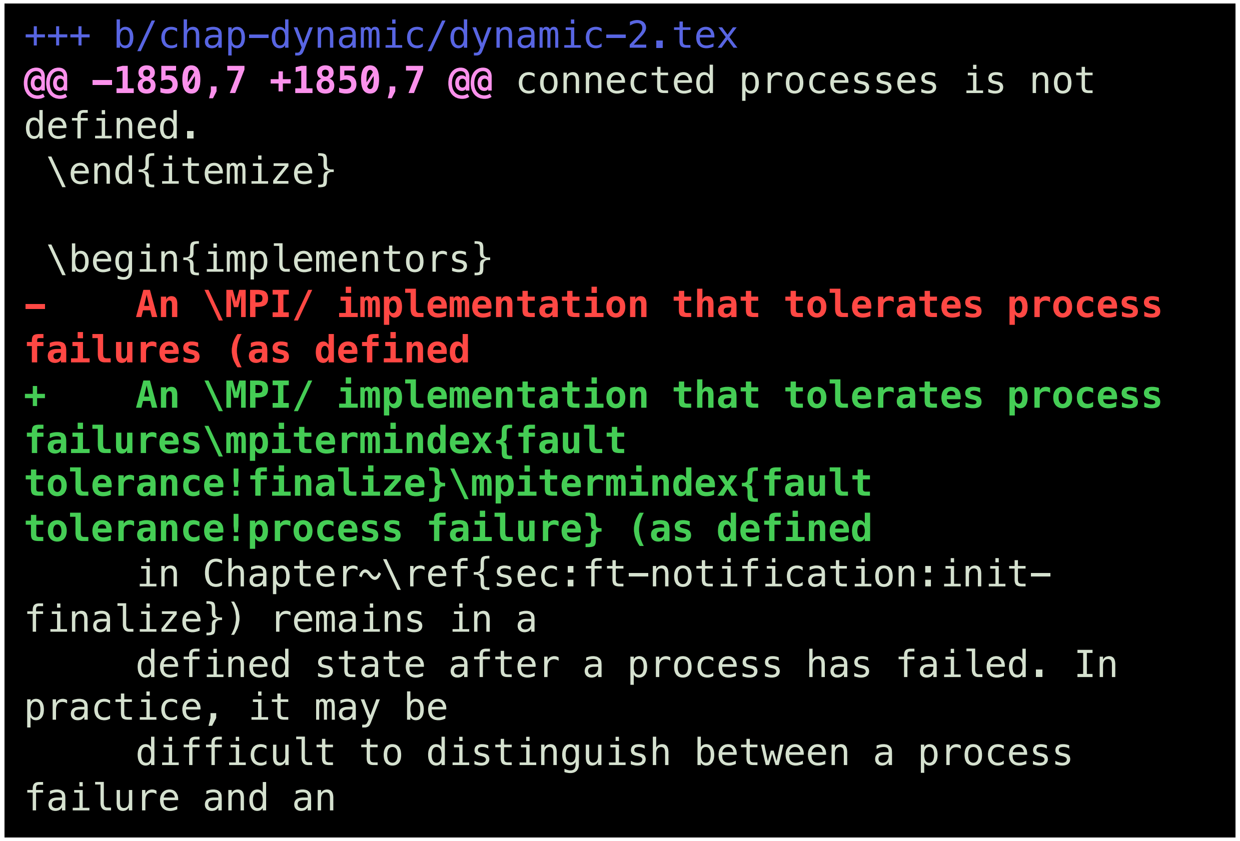
Changes since Sept. Reading



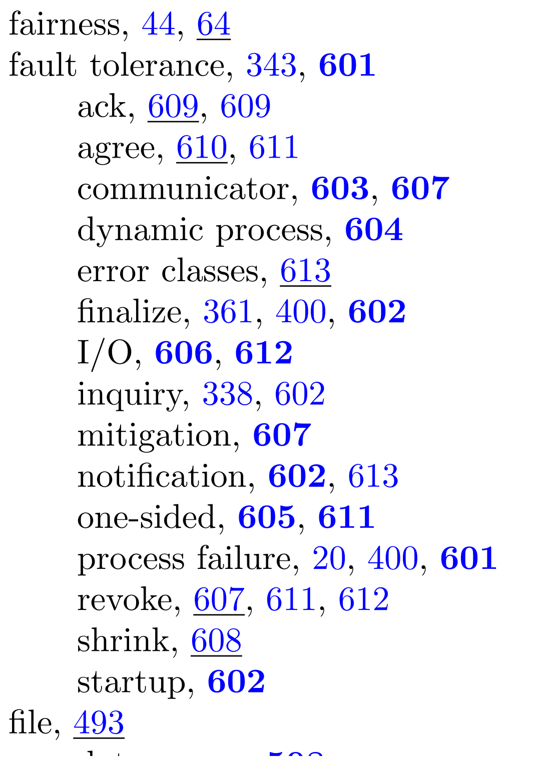
```
$ git log
5dec522 (HEAD -> ulfm/master) Merge branch 'mpi-3.x' into ulfm/master
Aurélien Bouteiller  13 days ago
10c8bdd (origin/ulfm/sept16/index, origin/ulfm/master, ulfm/sept16/index)
Adding index terms   Aurélien Bouteiller  13 days ago
bf6ec8e reordering comm_join Bouteiller  2 weeks ago
403a67f (origin/ulfm/sept16/spawn, ulfm/sept16/spawn) Clarification of Spawn
and hard/soft semantic...n Bouteiller  2 weeks ago
d84e6a1 more t0 Aurélien Bouteiller  2 weeks ago
d398ace (origin/ulfm/sept16/t0, ulfm/sept16/t0) Fix the changelog Aurélien
Bouteiller  2 weeks ago
7ced80c raise exceptions-> raise an error of class Aurélien Bouteiller  2 weeks
ago
a76b04b (origin/ulfm/sept16/shrinkv3, ulfm/sept16/shrinkv3) Reworking SHRINK
according to Sept. 2016....Bouteiller  2 weeks ago
bd98b37 Fix incorrect use of MPI_ERR_CLASS Wesley Bland  3 weeks ago
f3d81b9 Add "at that process" also to qualify where it becomes local Aurélien
Bouteiller 10 weeks ago
443acc1 (origin/ulfm/sept16/statusv2, ulfm/sept16/statusv2) Have only error
codes remain defined in ....Bouteiller 10 weeks ago
```

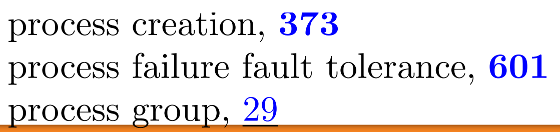
Index

- Rolf reported we were missing general index terms
  - We had the C/Fotran indexes, but missing the ”terms” index
- Important Terms have been added to the index (pp738,739)



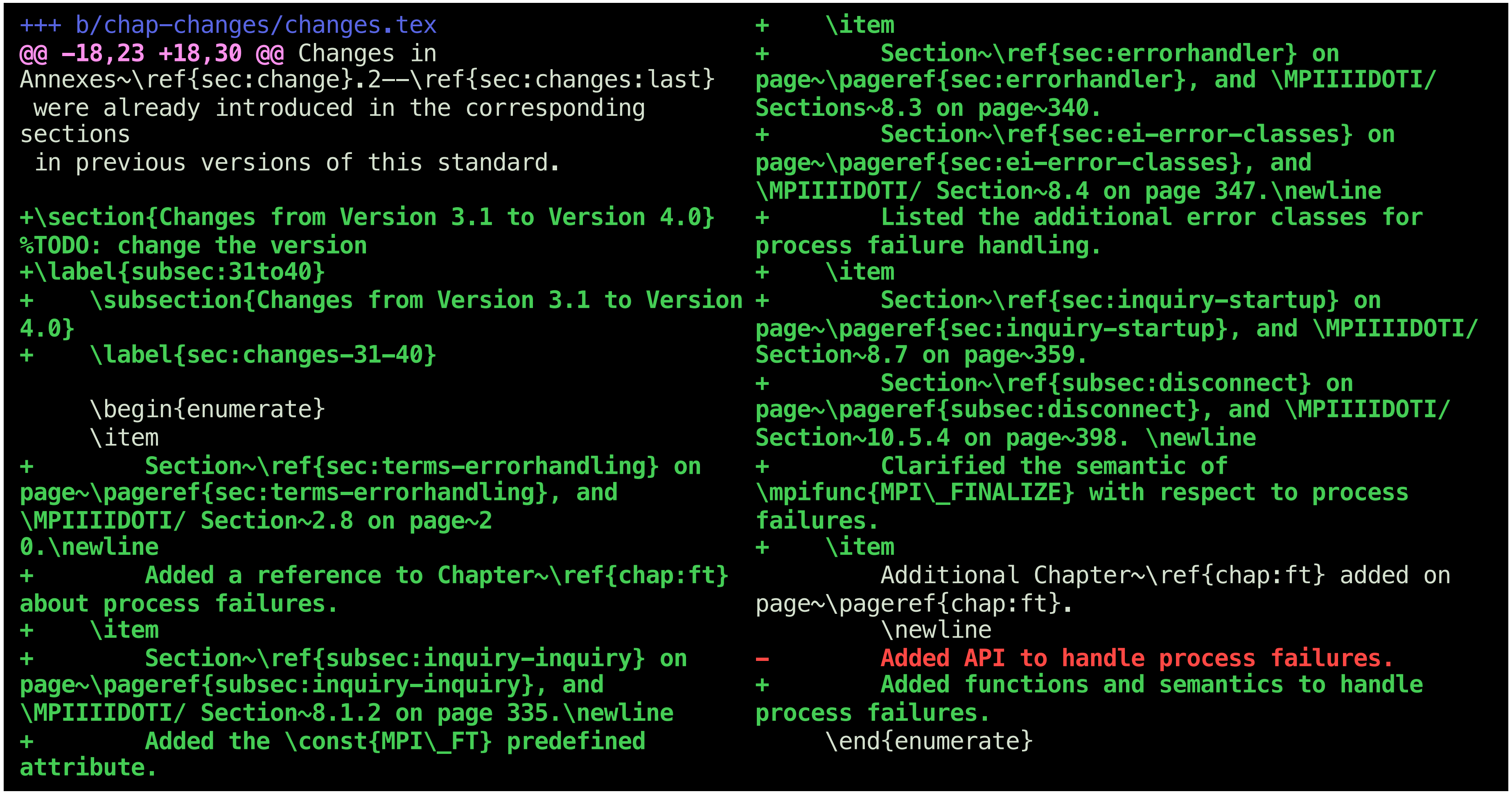
```
+++ b/chap-dynamic/dynamic-2.tex
@@ -1850,7 +1850,7 @@ connected processes is not
defined.
 \end{itemize}

 \begin{implementors}
-    An \MPI/ implementation that tolerates process
failures (as defined
+    An \MPI/ implementation that tolerates process
failures\mpitermindex{fault
tolerance!finalize}\mpitermindex{fault
tolerance!process failure} (as defined
     in Chapter~\ref{sec:ft-notification:init-
finalize}) remains in a
     defined state after a process has failed. In
practice, it may be
     difficult to distinguish between a process
failure and an
```





Changelog

- Changelog modified using macros and standard “look n feel”
    - Put in page ordering as it should



```
+++ b/chap-changes/changes.tex
@@ -18,23 +18,30 @@ Changes in
Annexes~\ref{sec:change}.2--\ref{sec:changes:last}
 were already introduced in the corresponding
sections
 in previous versions of this standard.

+\section{Changes from Version 3.1 to Version 4.0}
%TODO: change the version
+\label{subsec:31to40}
+    \subsection{Changes from Version 3.1 to Version
4.0}
+    \label{sec:changes-31-40}

     \begin{enumerate}
     \item
+        Section~\ref{sec:terms-errorhandling} on
page~\pageref{sec:terms-errorhandling}, and
\MPIIIIDOTI/ Section~2.8 on page~2
0.\newline
+        Added a reference to Chapter~\ref{chap:ft}
about process failures.
+    \item
+        Section~\ref{subsec:inquiry-inquiry} on
page~\pageref{subsec:inquiry-inquiry}, and
\MPIIIIDOTI/ Section~8.1.2 on page 335.\newline
+        Added the \const{MPI\_FT} predefined
attribute.
+    \item
+        Section~\ref{sec:errorhandler} on
page~\pageref{sec:errorhandler}, and \MPIIIIDOTI/
Sections~8.3 on page~340.
+        Section~\ref{sec:ei-error-classes} on
page~\pageref{sec:ei-error-classes}, and
\MPIIIIDOTI/ Section~8.4 on page 347.\newline
+        Listed the additional error classes for
process failure handling.
+    \item
+        Section~\ref{sec:inquiry-startup} on
page~\pageref{sec:inquiry-startup}, and \MPIIIIDOTI/
Section~8.7 on page~359.
+        Section~\ref{subsec:disconnect} on
page~\pageref{subsec:disconnect}, and \MPIIIIDOTI/
Section~10.5.4 on page~398. \newline
+        Clarified the semantic of
\mpifunc{MPI\_FINALIZE} with respect to process
failures.
+    \item
         Additional Chapter~\ref{chap:ft} added on
page~\pageref{chap:ft}.
         \newline
-        Added API to handle process failures.
+        Added functions and semantics to handle
process failures.
     \end{enumerate}
```

Exceptions -> error codes

- From Bill during Sept 16 reading
  - The terminology "raise an exception of class …" is unusual
  - Correct terminology is "raise the error code(s) …"
- Multiple instances have been replaced (examples below)

```
\error{MPI\_ERR\_REVOKED} at that process. Once a window has been
 revoked at a process, all subsequent RMA operations on that window
 are considered local and RMA synchronizations must complete by
-raising an exception of class \error{MPI\_ERR\_REVOKED} at that
+raising an error of class \error{MPI\_ERR\_REVOKED} at that
 process. In addition, the current epoch is closed and RMA operations
 originating from this process are interrupted and completed with
 undefined outputs.
```

```
The mechanisms for handling process failures are defined in
Chapter~\ref{chap:ft}.
 When a process failure happens, the \MPI/ implementation may raise one of the
\MPI/
-exceptions related to process failure as defined in that chapter.
+error classes related to process failure as defined in that chapter.
 In this case, the \MPI/ implementation is still in a defined state and
continues to operate.
```

Bug in Example

- Putting the error code from MPI_Error_class in the error class variable is wrong
  - Found by Geoffroy Vallee

```
@@ -1021,7 +1020,7 @@ while( gnorm > epsilon ) {
     /* Add a computation iteration to converge and
        compute local norm in lnorm */
     rc = MPI_Allreduce(&lnorm, &gnorm, 1, MPI_DOUBLE,
MPI_MAX, comm);
-    ec = MPI_Error_class(rc, &ec);
+    MPI_Error_class(rc, &ec);

     if( (MPI_ERR_PROC_FAILED == ec) ||
         (MPI_ERR_REVOKED == ec) ||
```

Intro chapter missing a short descriptive of Chapt 15 (FT)

- All chapters have a short introduction
  - Additional chapter 15 found (myself proof reading) to not have one
  - Short intro added for uniformity

```
+++ b/chap-intro/intro.tex
@@ -459,6 +459,12 @@ analyzers, and other tools to obtain data about the
operation of \MPI/
 processes.  This chapter includes Section~\ref{sec:prof} (\nameref{sec:prof}),
 which was a chapter in previous versions of \MPI/.
 \item
+Chapter~\ref{chap:ft}, \nameref{chap:ft},
+covers interfaces that allow developers to design applications tolerant to
+process failures. The interfaces presented in this chapter define the state
+of the \MPI/ library after a process crash, and provide supplementary
+interfaces to restore the communication capabilities of \MPI/.
+\item
 Chapter~\ref{chap:deprecated}, \nameref{chap:deprecated}, describes routines
that
 are kept for reference. However usage of these functions is discouraged, as
 they may be deleted in future versions of the standard.
```

Error codes remain defined but the remainder of status remains undefined,

- During the Sept 16. plenary, it was decided that the status should remain an undefined output parameter (although as noted during the June 16 plenary, the ERROR field must remain defined, duh).

```diff
 a synchronizing operation may not have synchronized) and
 the content of the output buffers, targeted memory, or
-output parameters (except for status objects and error
return codes) is \emph{undefined}. Exceptions to this
+output parameters. Exceptions to this
 rule are explicitly stated in the remainder of this
chapter.
+Error codes returned from a function, output in arrays of
error codes, or
+in status objects remain defined after an operation raised
a
```

Shrink

- ”failed processes” contributing implicitly found confusing
  - Definition now explicit the content of the groups of the produced communicator

```diff
@@ -502,23 +517,22 @@ This collective operation creates a new intra- or intercommunicator
 respectively, by excluding the group of failed processes as agreed
 upon during the operation.
 %
-The group of \mpiarg{newcomm} must include (at least) every process that returns from
-\mpifunc{MPI\_COMM\_SHRINK}, and it must exclude (at least)
+The groups of \mpiarg{newcomm} must include every process that returns from
+\mpifunc{MPI\_COMM\_SHRINK}, and it must exclude
 every process whose failure caused an operation on \mpiarg{comm} to raise an
+\MPI/ error of class
 \error{MPI\_ERR\_PROC\_FAILED} or
 \error{MPI\_ERR\_PROC\_FAILED\_PENDING}
-at a member of the group of \mpiarg{newcomm}, before that member initiated
+at a member of the groups of \mpiarg{newcomm}, before that member initiated
 \mpifunc{MPI\_COMM\_SHRINK}.
 %
 This call is semantically equivalent to an
 \mpifunc{MPI\_COMM\_SPLIT} operation that would succeed despite
-failures, where processes participate with the same
-color and a key equal to their rank in \mpiarg{comm}, except failed
-processes, which implicitly contribute the color \const{MPI\_UNDEFINED}.
+failures, where members of the groups of \mpiarg{newcomm} participate with the same
+color and a key equal to their rank in \mpiarg{comm}.
```

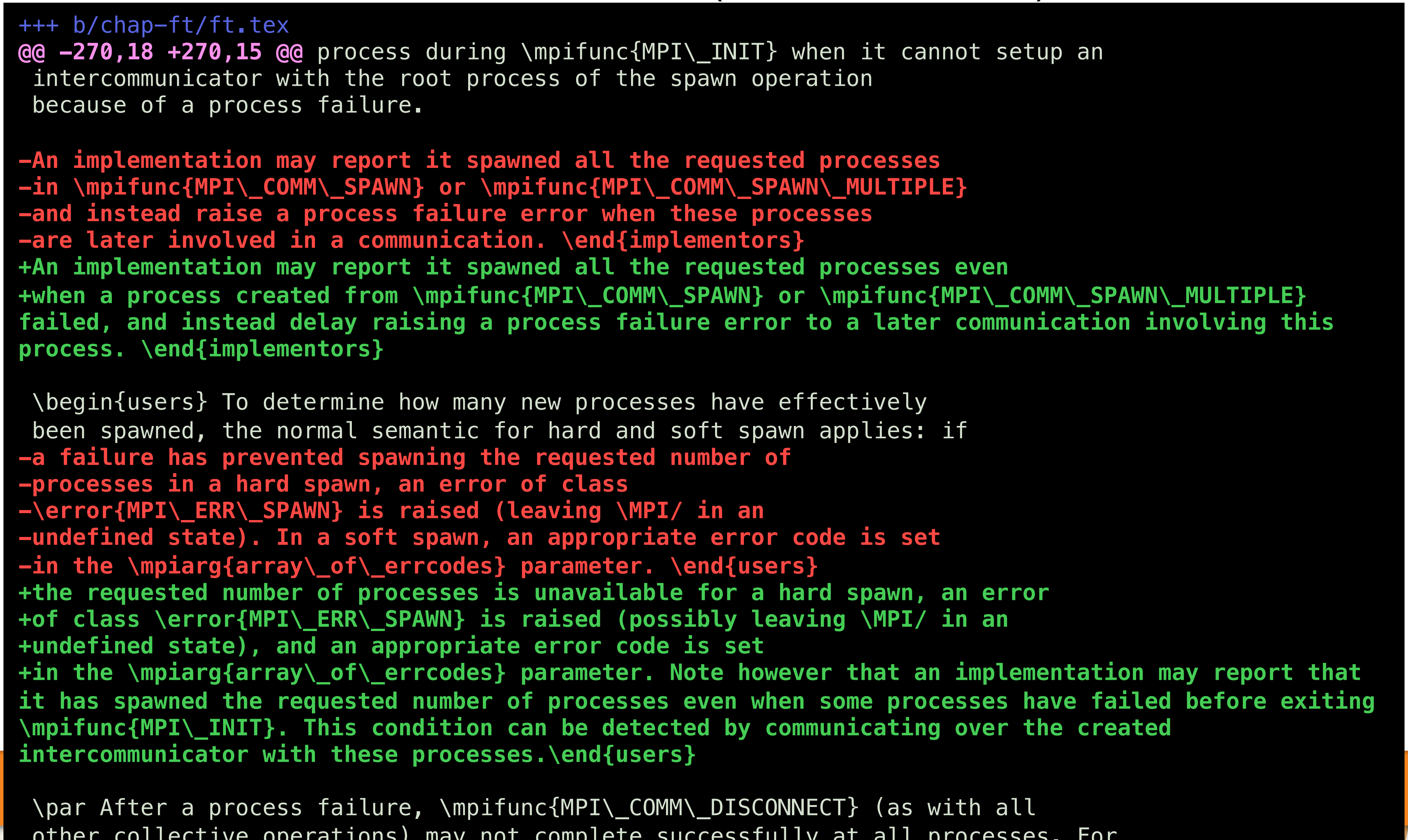
MPI_Comm_Disconnect semantic

- The semantic (and text) is identical to MPI_Comm_free

```
+++ b/chap-ft/ft.tex
@@ -290,6 +290,23 @@ processes in a hard spawn, an exception of class
 undefined state). In a soft spawn, an appropriate error code is set
 in the \mpiarg{array\_of\_errcodes} parameter. \end{users}

+\par After a process failure, \mpifunc{MPI\_COMM\_DISCONNECT} (as with all
+other collective operations) may not complete successfully at all ranks. For
+any rank that receives the return code \const{MPI\_SUCCESS}, the behavior is
+defined in~\ref{subsec:disconnect}. If a rank raises a process failure
+exception (\error{MPI\_ERR\_PROC\_FAILED} or \error{MPI\_ERR\_REVOKED}), the
+communicator handle \mpiarg{comm} is set to \const{MPI\_COMM\_NULL}; however,
+the implementation makes no guarantee about the success or failure of the
+\mpifunc{MPI\_COMM\_DISCONNECT} operation, locally or remotely.
+
+\begin{users} Users are encouraged to call \mpifunc{MPI\_COMM\_DISCONNECT}
+    on communicators they do not wish to use anymore, even when they
+    contain failed processes. Although the operation may raise a
+    process failure exception and not synchronize properly, this
+    gives a high quality implementation an opportunity to release
+    local resources and memory consumed by the object.
+\end{users}
+
```

MPI_Comm_spawn soft/hard

- Text found too oblique/unclear during Sept 16 reading
- Text verified for correctness (found correct) and clarified



```
+++ b/chap-ft/ft.tex
@@ -270,18 +270,15 @@ process during \mpifunc{MPI\_INIT} when it cannot setup an
 intercommunicator with the root process of the spawn operation
 because of a process failure.

-An implementation may report it spawned all the requested processes
-in \mpifunc{MPI\_COMM\_SPAWN} or \mpifunc{MPI\_COMM\_SPAWN\_MULTIPLE}
-and instead raise a process failure error when these processes
-are later involved in a communication. \end{implementors}
+An implementation may report it spawned all the requested processes even
+when a process created from \mpifunc{MPI\_COMM\_SPAWN} or \mpifunc{MPI\_COMM\_SPAWN\_MULTIPLE}
failed, and instead delay raising a process failure error to a later communication involving this
process. \end{implementors}

 \begin{users} To determine how many new processes have effectively
 been spawned, the normal semantic for hard and soft spawn applies: if
-a failure has prevented spawning the requested number of
-processes in a hard spawn, an error of class
-\error{MPI\_ERR\_SPAWN} is raised (leaving \MPI/ in an
-undefined state). In a soft spawn, an appropriate error code is set
-in the \mpiarg{array\_of\_errcodes} parameter. \end{users}
+the requested number of processes is unavailable for a hard spawn, an error
+of class \error{MPI\_ERR\_SPAWN} is raised (possibly leaving \MPI/ in an
+undefined state), and an appropriate error code is set
+in the \mpiarg{array\_of\_errcodes} parameter. Note however that an implementation may report that
it has spawned the requested number of processes even when some processes have failed before exiting
\mpifunc{MPI\_INIT}. This condition can be detected by communicating over the created
intercommunicator with these processes.\end{users}

 \par After a process failure, \mpifunc{MPI\_COMM\_DISCONNECT} (as with all
 other collective operations) may not complete successfully at all processes. For
```