PMIx Fault Events Detection and Dissemination use case: Fault-Tolerance in Open MPI 5 and more

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PMIX Fault events use cases
ULFM available in Open MPI 5.0
SUNY OSHMEM, and more

MOTIVATION

MPI ULFM

- Detection and propagation in the scope of MPI_COMM_WORLD and MPI process
- Need capability to handle node failures and not limited to any MPI

OpenSHMEM

- No fault tolerance model in current code stack.
- Need failure detection and propagation service to trigger check-pointing and restart.

MPI EREINIT

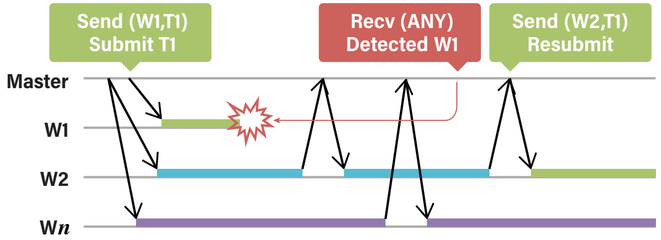
- Global-restart failure recovery by fast re-initialization of MPI
- In need of more efficient and generic service

DataSpaces and FTI

- Persistent data storage services with check-pointing feature.
- Need basic service for to detect and report failures of distributed storage service.

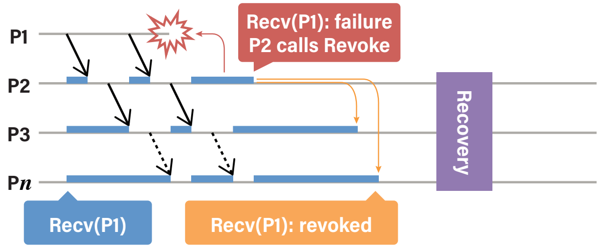
Continue across Errors

In ULFM, failures do not alter the state of MPI communicators. Point-to-point operations can continue undisturbed between non-faulty processes. ULFM imposes no recovery cost on simple communication patterns that can proceed despite failures.



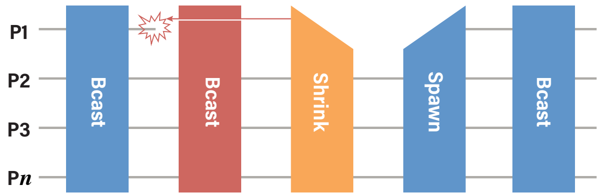
Exceptions in Contained Domains

A process can use MPI_[Comm,Win,File]_revoke to propagate an error notification on the entire group, and could, for example, interrupt other ranks to join a coordinated recovery.



Full-Capability Recovery

Allowing collective operations to operate on damaged MPI objects (communicators, RMA windows, or files) would incur unacceptable overhead. The MPI_Comm_shrink routine builds a replacement communicator—excluding failed processes—that can be used to resume collective operations in malleable applications, spawn replacement processes in non-moldable applications, and rebuild RMA windows and files.



Example use cases: continue without repair, repair in domains, respawn missing processes with ULFM MPI

PMIx Fault Events Interface

Dong Zhong, Aurelien Bouteiller, Xi Luo, and George Bosilca. 2019. **Runtime Level Failure Detection and Propagation in HPC Systems.** In 26th European MPI Users' Group Meeting (EuroMPI 2019), September 11–13, 2019, Zürich, Switzerland. *https://doi.org/10.1145/3343211.3343225*

FRONT END: PMIx Interface

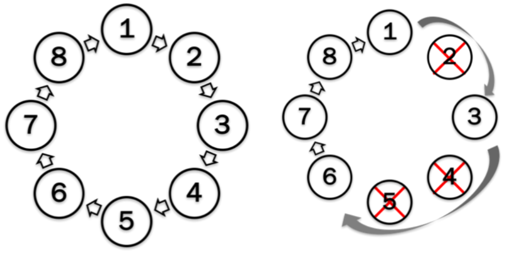
- Control of the detection service through PMIx interfaces
- **Fault Events are presented as normal PMIx Events**
- Very simple to hook into
- Compatible with non-ft builds (event is just not generated)

  - PMIX_Register_event_handler(..., PMIX_ERR_PROC_ABORTED, ...)

- Opens the gate for efficient management of failures for an emerging field of libraries, programming models, and runtime systems operating on large-scale systems.
- Well specified interface helps **usability by multiple client types**

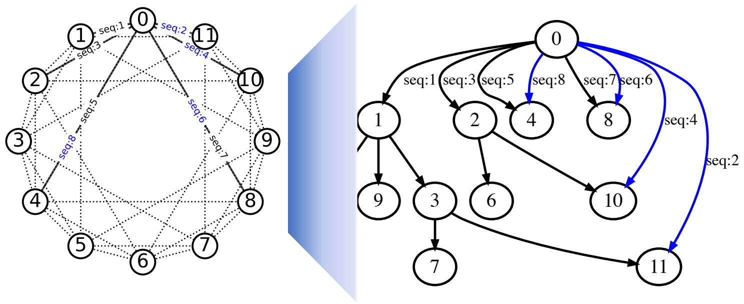
BACK END Capability integrated in **PRTE 2.0,** other LM/SMS can produce the same events using their own methodologies

FAILURE DETECTION COMPONENT



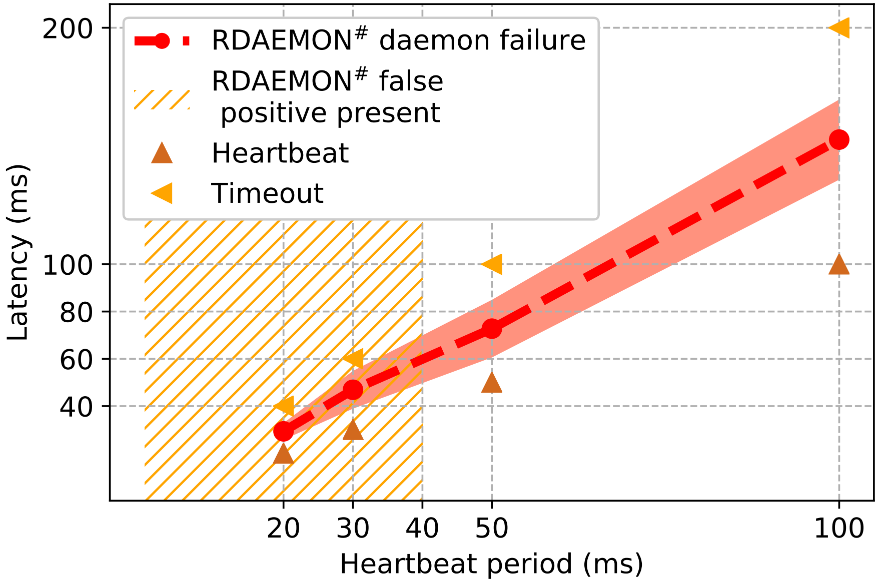
Node/PRTE servers failure detected with **ping on a mendable ring**
Minimal ping noise

RELIABLE EVENT PROPAGATION COMPONENT



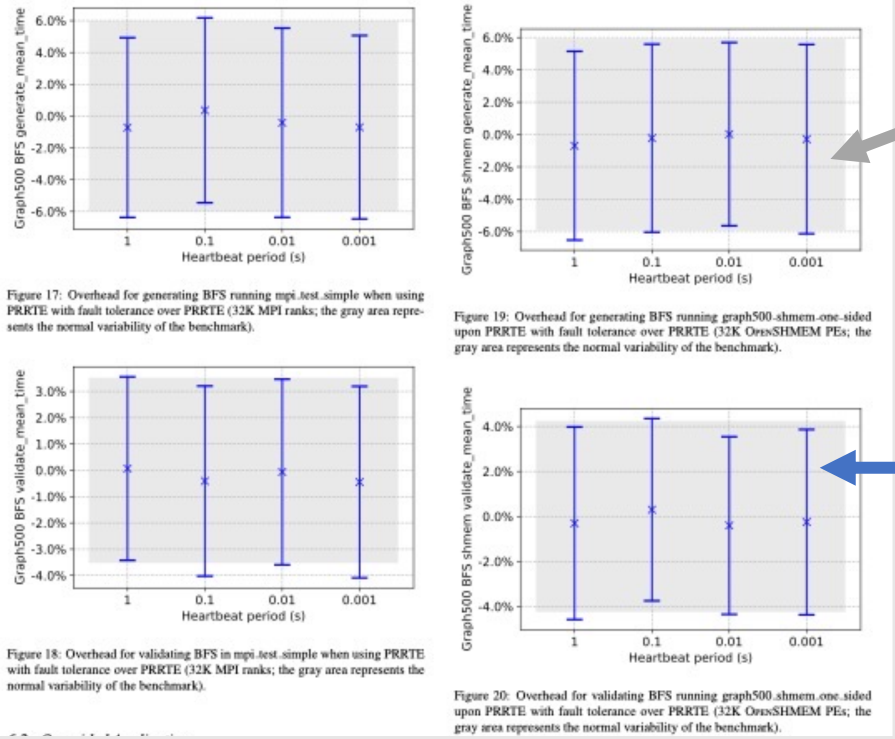
Event Propagation along **multiple binomial trees** extracted from a circulant graph: **fixed degree (log), fast and resilient**

Advantages in delegating detection to the PMIx runtime



- Accuracy of detection is very good (in the order of 100ms can be achieved in practice at scale)
- False detection rate **independent of the application communication pattern**
  - *Prior MPI-based detector would produce false positive when application does not call MPI procedures*
- *Reusable in different programming models*

Performance variability in **GRAPH500 with an active PMIx-PRRTE Failure detector**
Left: **MPI** Right: **OpenSHMEM**



Gray area represents normal benchmark variability

Blue error bars show the variability as measured with detection ON

Experiments performed on NERSC's Cori: Cray XC40 supercomputer with Intel Xeon "Haswell" processors and the Cray "Aries" high speed inter-node network, 32 cores per node, 32K processes total.

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Fault Management in PMIx What works, and Future Directions

- PMIx Event Handling proved to be a natural fit to disseminate fault events
- PMIx abstracts the ‘detector’, which lets application write portable fault-tolerant code that can operate on a variety of PMIx servers (including non-FT ones)
- PMIx servers have freedom of implementation behind the API curtain

Future Extensions

- Fault-events implemented only in PRTE at the moment (PRTE can be launched under Slurm/Jsrun/ALPS, etc., in managed mode, but not all have native support yet).
- Current enabling of fault-detection/management is command-line based
- Can we move to a programmatic way to turn-on/turn-off resilient features?
- PRTE: Resilient overlay communication for commands/modex (reduce vulnerability to startup faults)
- Could user have fine-grain control over what operation (e.g., PMIx modex or Fence) are resilient, or not (performance optimization)?

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