# Resilience / Fault Injection Research



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# Resilience / Fault Injection Research

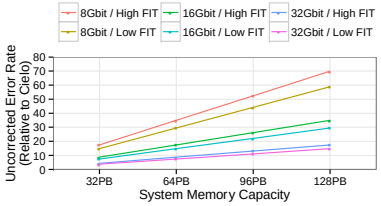
Los Alamos NATIONAL LABORATORY EST.1943

## Studying Application Response to Faults Paves the Path for Next Generation HPC

## BACKGROUND & MOTIVATION

**Supercomputing technology is undergoing unprecedented changes that impact resilience of systems and applications.**

- Fault characterization provides insight into faults experienced today and allows estimates of the future
- By injecting faults into apps and systems we can learn what to expect and how to improve systems of tomorrow.




## INNOVATION

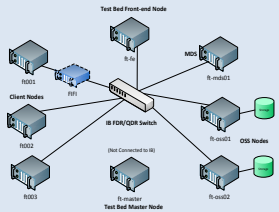
**End-to-End Resilience Story and Experimentation Framework**

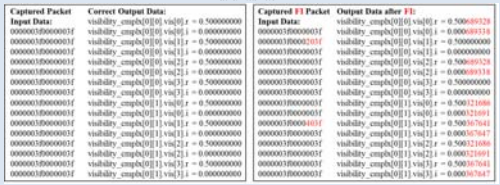
- Take real applications of importance
- Study them under real workloads (full operating systems, middleware, etc.)
- Inject faults with precision at the virtual architecture level.
- Inject faults with precision in the network data.
- How does the application behave in these conditions?
- Campaign studies of fault-tolerance
- Improve the application, empirically study the improvements to make more resilient systems.

## DESCRIPTION

**Field Data From Today Influences Predictions For Tomorrow and Facilitates Fault Injection Experiments to Understand Application Responses**

- Studied DRAM and SRAM faults across 3 DOE supercomputing centers
  - ~50 billion DRAM hours, largest studies of their kind.
  - Directly impacting next generation HPC products
- F-SEFI used to “dial in” real error rates of today and expectations of tomorrow: how do applications of interest fare?
- FIFI is the only network-level I/O fault injector for IB 4x QDR (40 Gb/s)
- Can be placed in system without altering network configuration and applications
- Extremely low latency (< 300 nanoseconds) to minimize system perturbations
- Choice of packets/words/bits for FI made at random or deterministically



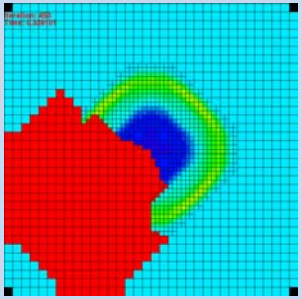



**TRL 5-6:** FIFI tested and verified via pilot study/ongoing I/O testing. F-SEFI demonstrated on a host of apps including LANL hydrodynamics mini-app, CLAMR

## ANTICIPATED IMPACT

**Fault Injection Experiments in Real Applications Provides Insight**

- Insights from F-SEFI experiments provide guidance to hydrodynamics app developers.
- Lead to detection and correction work to become resilient to soft errors
- Empirically tested and measured



## PATH FORWARD

**Implement outside LANL:**

- Utilize F-SEFI and FIFI in fault testing to enable end-to-end resilience research
- Future FIFIs address newer and faster I/O interconnects, e.g., 100Gb/s and beyond
- Produce test methodologies and suites to facilitate resilience analysis of applications and systems

**Potential End Users:**

- DOE/DOD/other government agencies
- HPC researchers and vendors
- Science application developers

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