Improving Fault Resilience of High Performance Applications

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The Problem

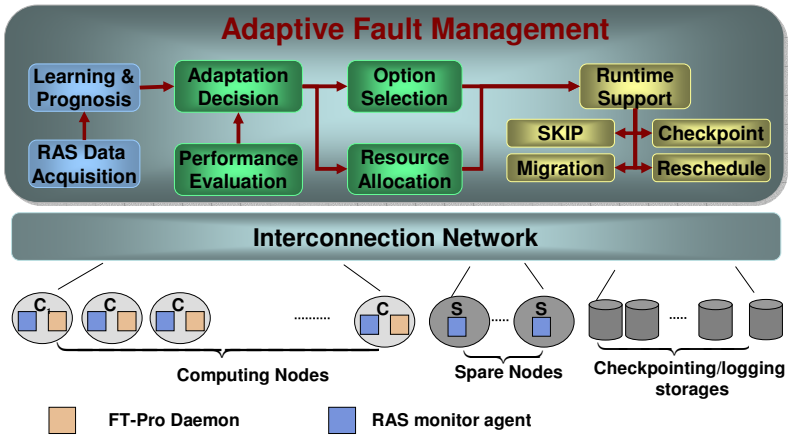
Reliability is becoming a fundamental challenge to the continuous scaling of HPC

- Failure rates accelerate dramatically as the size and complexity of HPC systems grows, e.g. tens-of-thousands to hundreds-of-thousands of processing components
- The inherent parallel paradigm makes HPC applications more failure-prone, e.g. a single component failure crashes the entire application

A new fault tolerance approach is needed for the present and future HPC

- The conventional checkpointing/recovery approach is not efficient, e.g. rollback, overhead, downtime…
- The emerging proactive approach is not reliable, e.g. false alarms and prediction misses

Proposed Solution



Fault learning and prediction [1]

- Statistical learning
- Rule-based mining
- Advanced learning

Performance-based adaptive strategy[2]

- Opportunistic SKIP, to reduce unnecessary fault tolerance operations;
- Selective CKP, to reduce potential performance loss caused by unforeseeable failures;
- Preemptive migration, to avoid anticipated failures

System support [3,4]

- System-wide fault-driven resource allocation and rescheduling
- Augment of open source MPI package

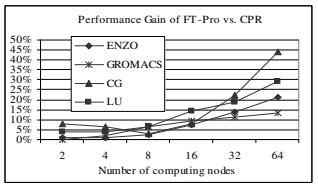
On-going Research

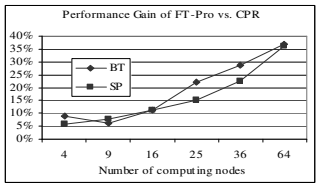
- **Online fault prediction**
- **Coupling of application adaptation with system adaptation**
- **Integration of different components as an end-to-end package**
- **Extensive evaluation and validation**

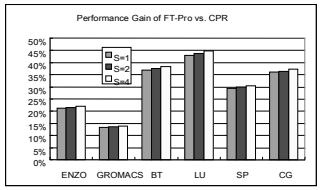
Reference

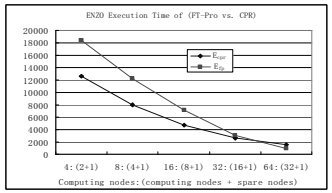
[1] P. Gujrati, Y. Li, Z. Lan, "Knowledge-based Fault Prediction on BlueGene/L systems", *Tech. Rep.*, IIT, 2006.
[2] Y. Li and Z. Lan, "Exploit Failure Prediction for Adaptive Fault Tolerance in Cluster Computing", *Proc. of IEEE CCGrid06*.
[3] Z. Lan,Y. Li, and J. Lee, "Exploring Large-scale Applications on TereGrid", *The First Annual TereGrid Conference*, 2006.
[4] Y. Li, P. Gujrati, Z. Lan, and X. Sun, "Study of Fault-Driven Rescheduling for Improving System-level Fault Resilience", submitted.

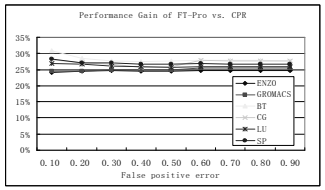
Case Studies

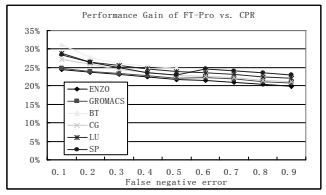












- **Integrate adaptive fault management with MPICH-V**
- **Compare with periodic CPR**

- **Testbed: IA32 cluster at TG/ANL**
- **Use an actual failure trace of HPC system**

- **Production HPC applications**
  (1) NPB benchmarks
  (2) Cosmology application ENZO
  (3) Molecular dynamic application GROMACS

- **Investigate the following issues:**
  (1) Impact of computing scale
  (2) Impact of prediction accuracy
  (3) Impact of spare node allocation