Leaping Shadows: Adaptive and Power-aware Resilience for Extreme-scale Systems

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Introduction

❖ System scale keeps growing for both HPC and Cloud.

	TODAY	FUTURE
Perfermance	20 Pf/s	1 Ef/s
Power	8 MW	20 MW
System size	18,688	100 K-1 M
Memory	0.7 PB	32-64 PB
Network BW	1.5 GB/s	100-1000 GB/s
I/O Capacity	15 PB	300-1000 PB

System level **failure rate** will dramatically increase

Power/energy will dominate CAPEX

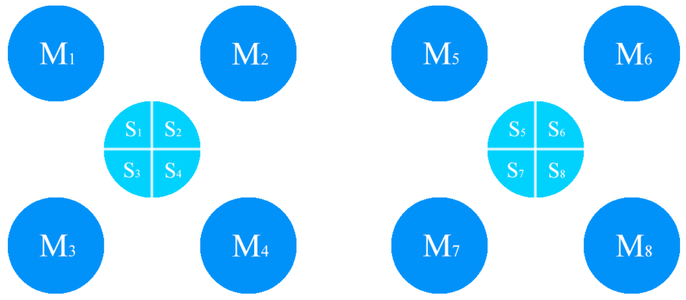
Low efficiency + **high cost**

Shadow Collocation

❖ Collocate multiple shadow processes on each node

❖ Reduces shadow processes' execution rate

❖ Reduces **hardware** and **power** requirement



World's #1 Open Science Supercomputer

Flagship accelerated computing system | 200-cabinet Cray XK7 supercomputer

18,688 nodes (AMD 16-core Opteron + NVIDIA Tesla K20 GPU)

CPUs/GPUs working together – GPU accelerates | 20+ Petaflops

Shadow Leaping

❖ The lagging shadow processes can benefit from the faster execution of the main processes

❖ Sync states from the main processes to the shadows

Overlap leaping with recovery

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Forward progress with **minimized power**

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Reduces main and shadow **distance**

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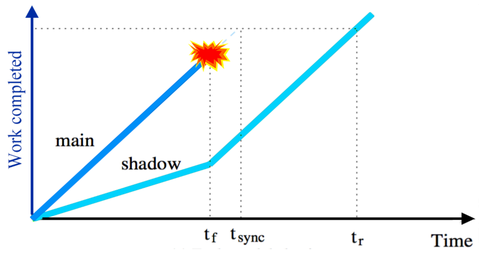
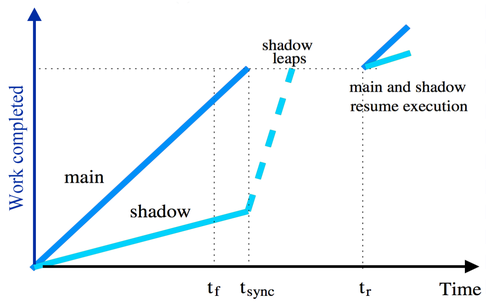
Minimizes subsequent **recovery time**



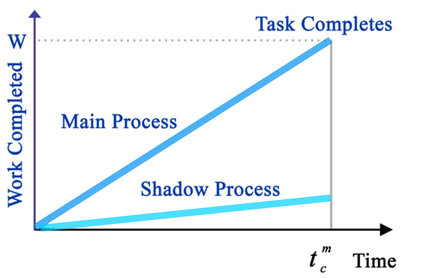


Lazy Shadowing

❖ Each process is associated with a "**shadow**"

❖ Shadow processes initially execute at reduced rate

❖ Upon failure of a main process, its shadow process increases execution rate to recover and complete task



Reduced execution rate

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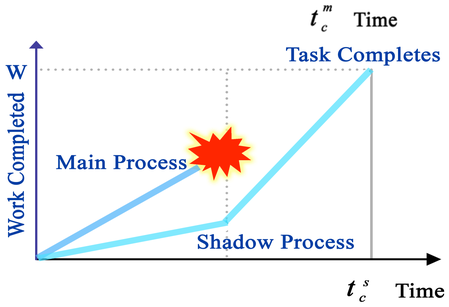
Power/Energy **savings**



Dynamic increase of rate upon **failure**

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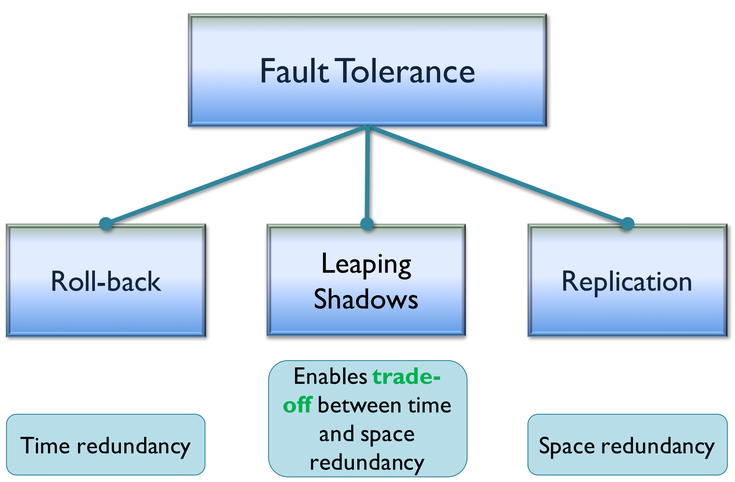
Delay **minimized**

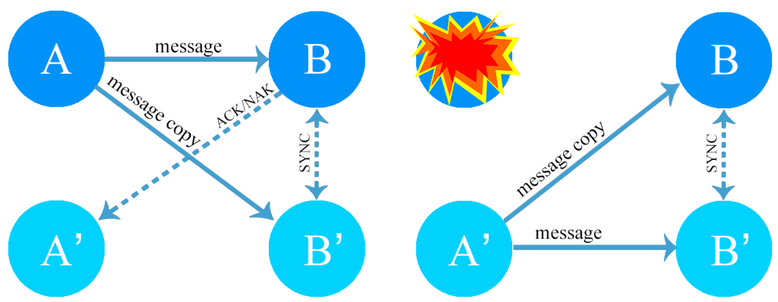
The Fault Tolerance Spectrum



MPI Implementation

❖ **lsMPI** lies between application and MPI that transparently supports Leaping Shadows

❖ Failure detection with User Level Fault Mitigation



❖ ACK/NAK is used to guarantee consistent promotion of a shadow process in the case of a failure

❖ Main process is responsible for resolving non-determinism, such as MPI_ANY_SOURCE receive, MPI_Wtime( )

❖ Collectives use lsMPI internal point-to-point communications

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