A Framework for Proactive Fault Tolerance

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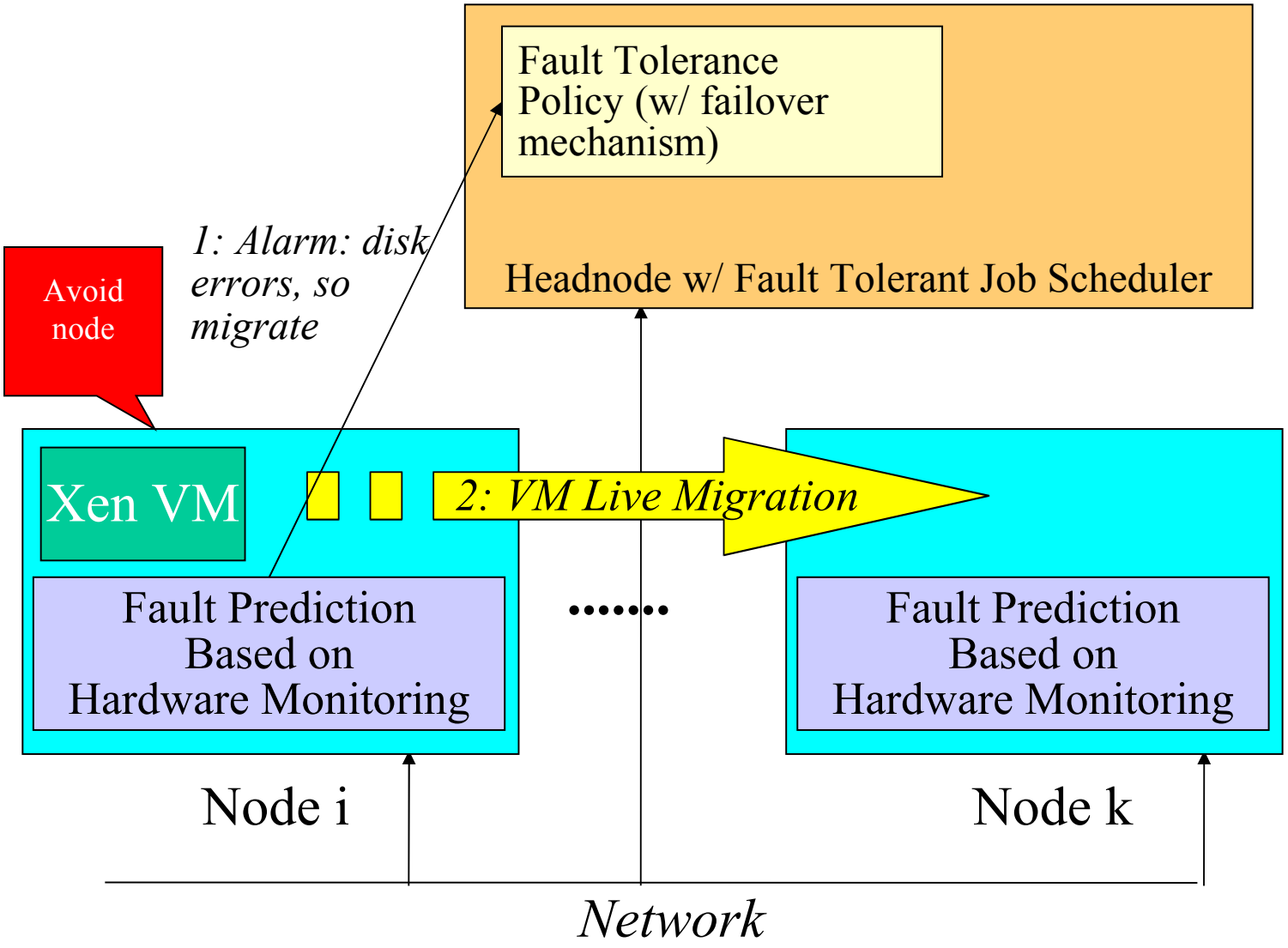
Context & Background

- **Large-scale systems & long running applications**
  - hundred of thousands of nodes, individual components can fail
  - specialized nodes (compute nodes vs. I/O nodes vs. login nodes)
  - avoid any kind of overhead on compute nodes (priority to applications)
  - Standard parallel applications (MPI-like applications)
- **No Fault Tolerance (FT) intelligence in most parallel applications**
- **Basic fault tolerance solutions**
  - Production: *reactive policies*, *i.e.*, how to react to a failure?
  - Research: *pro-active policies*, *i.e.*, how to anticipate failures?
- **Different execution platform characteristics**
  - Failure distribution
  - Predictable vs. unpredictable failures
  - Platform types: disk-less or disk-full

Only pro-active FT is in the scope of this presentation

Pro-active Fault Tolerance – Introduction



Pro-active Fault Tolerance Challenges

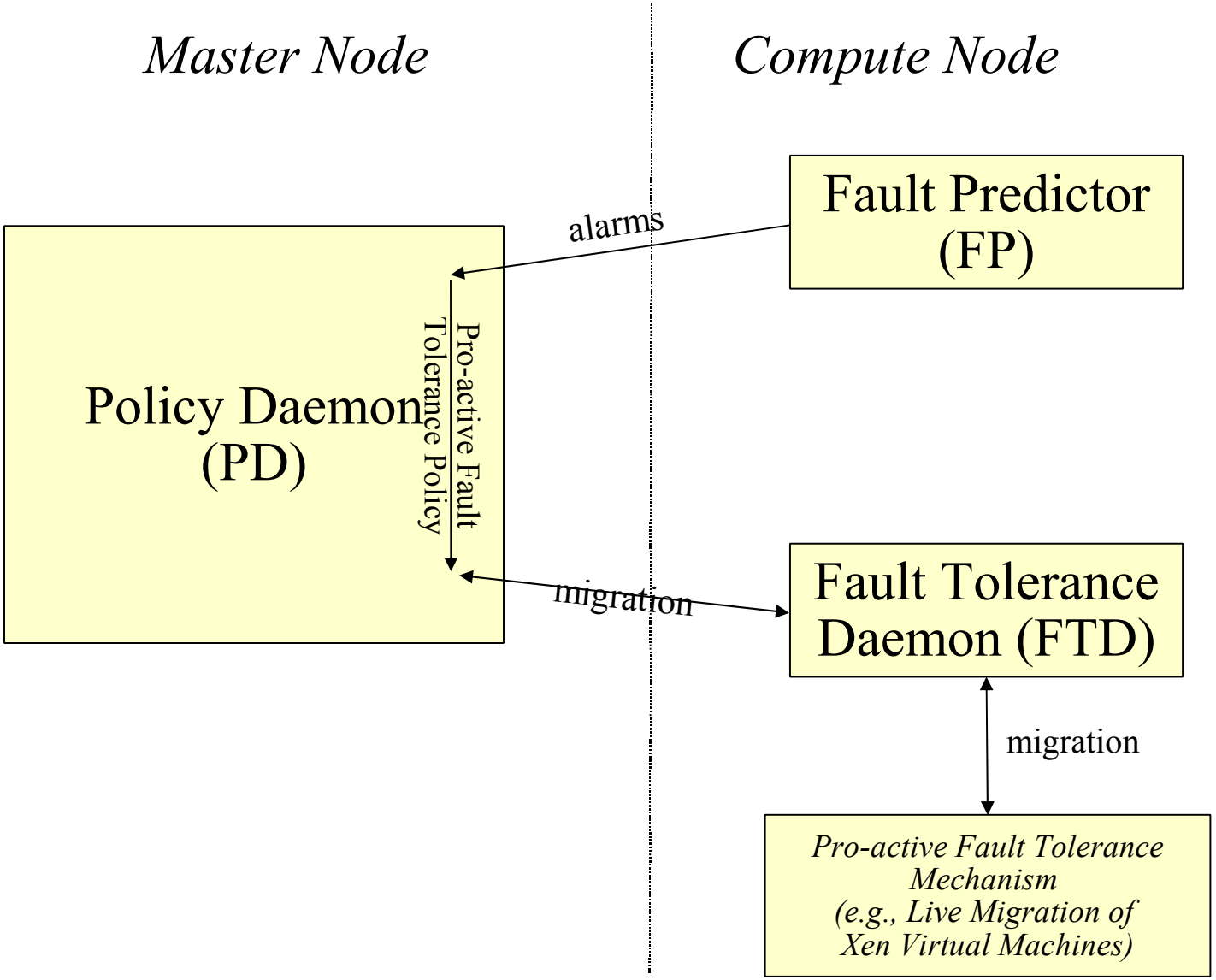
- Mechanisms challenges
  - fault prediction
  - prediction accuracy
  - application manipulation
    - migration
    - pause/unpause
- Policy challenges – adaptation to
  - platform characteristics
  - application characteristics

No one-fit all solution
=> proactive FT framework

Platform Architecture Overview

- **Specialized nodes**
  - **“master node”**
    - ***logical* centralized execution point for services**
    - **may NOT be a single node, it is a logical view of where the distributed services are hosted**
  - **compute nodes**
    - **where the application is running**
    - **should avoid interferences from the framework**
- **Communication sub-system**
    - **for scalability, we assume we reuse scalable communication sub-systems (*e.g.*, MRNet)**
    - **efficient way to “push” data to the master node**
    - **abstraction of the under-lying networking solutions**

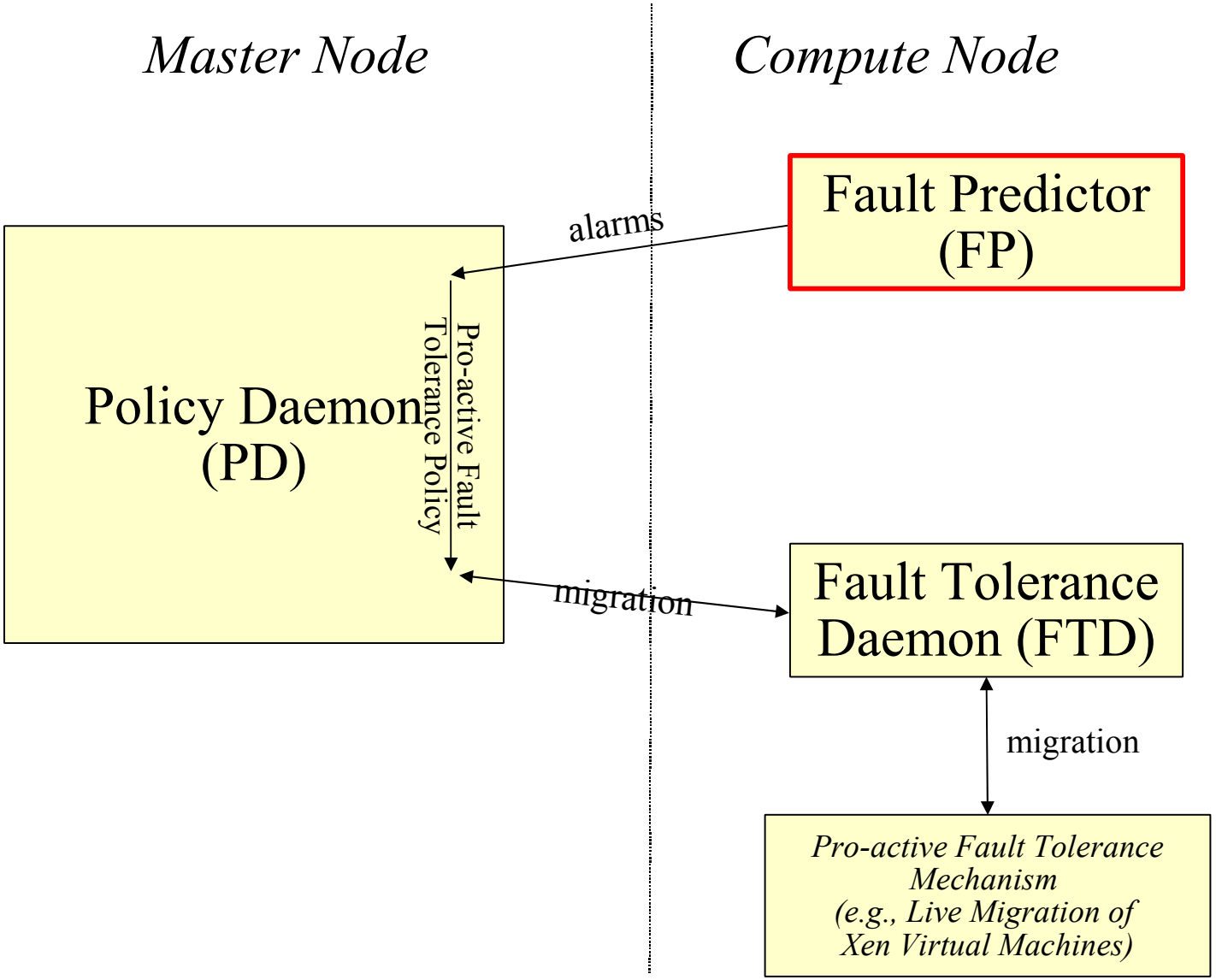
Pro-active FT Framework – Architecture



Framework Components – Event System

- Core of the framework: abstract all communications between framework components
- Abstract the underlying communication sub-system
  - abstraction of scalable sub-systems such as MRNet
  - abstraction of the physical network solution
- Based on the concepts of *mailbox*, *mailbox managers*, *subscribers*, and *publishers*
- Asynchronous, “tolerate failures” (*i.e.*, missing readers)
- Very low overhead when the system is healthy
- No interference with applications running on compute nodes

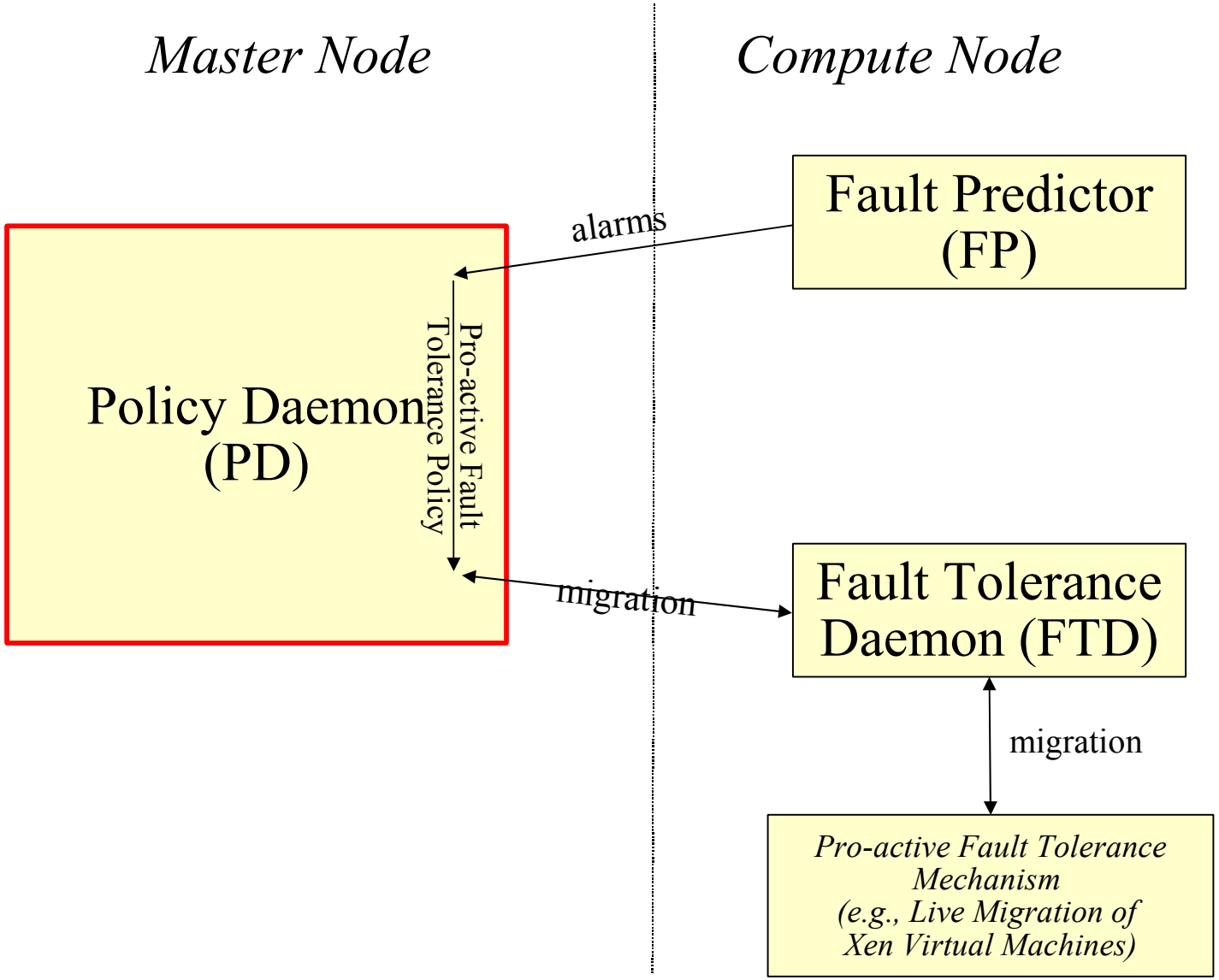
Pro-active FT Framework – Architecture



Framework Components – Fault Predictor

- Runs on each compute nodes
- Abstraction of the underlying mechanism for hardware monitoring and fault prediction (typically hardware probes)
- Filter data extracted from probes
- Prevent a global polling, creates an alarm only if probes report abnormal behavior (alarm sent to the policy daemon on the master node)
- Currently uses: lm-sensor, syslogs + experimental support of IPMI

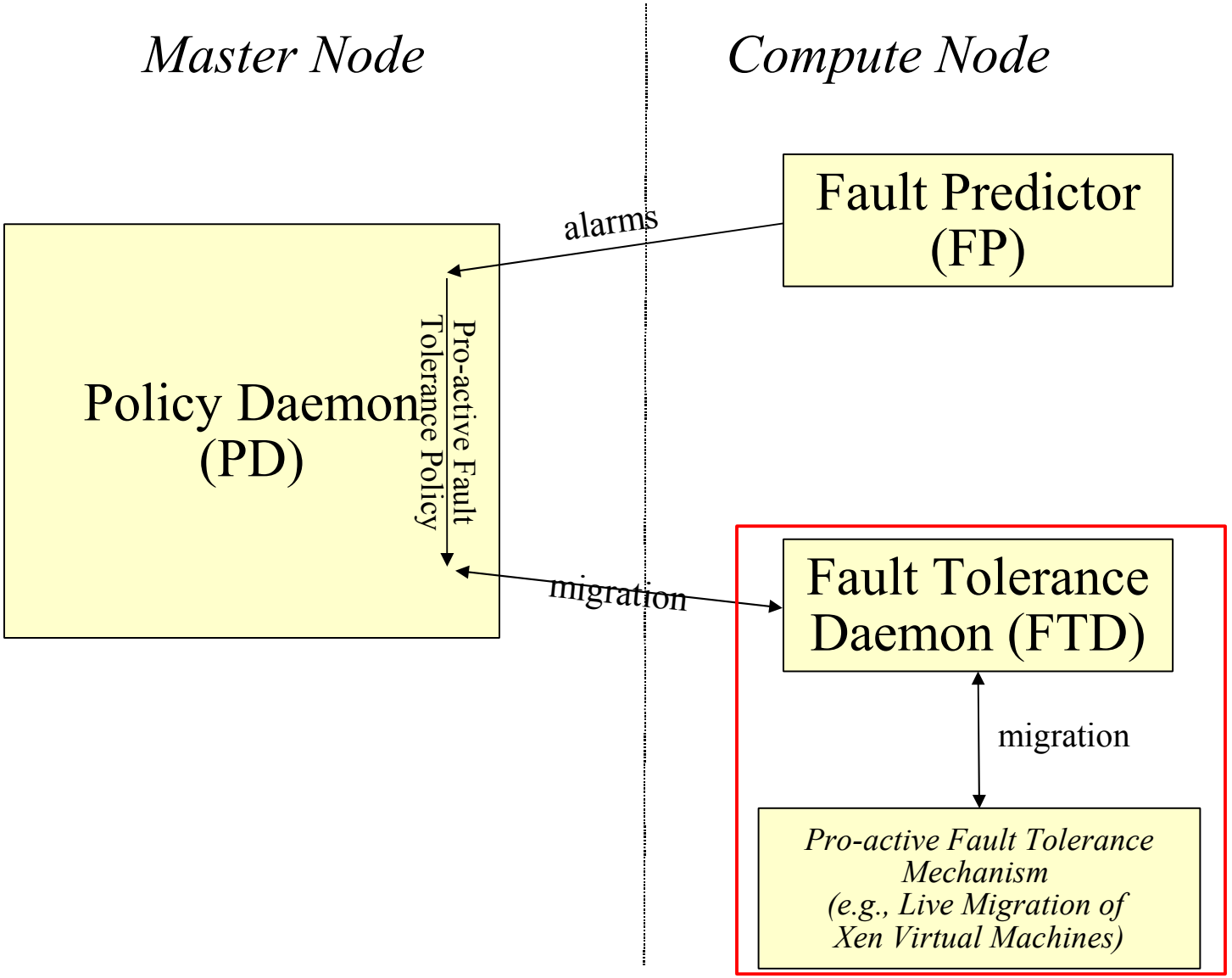
Pro-active FT Framework – Architecture



Framework Components – Policy Daemon

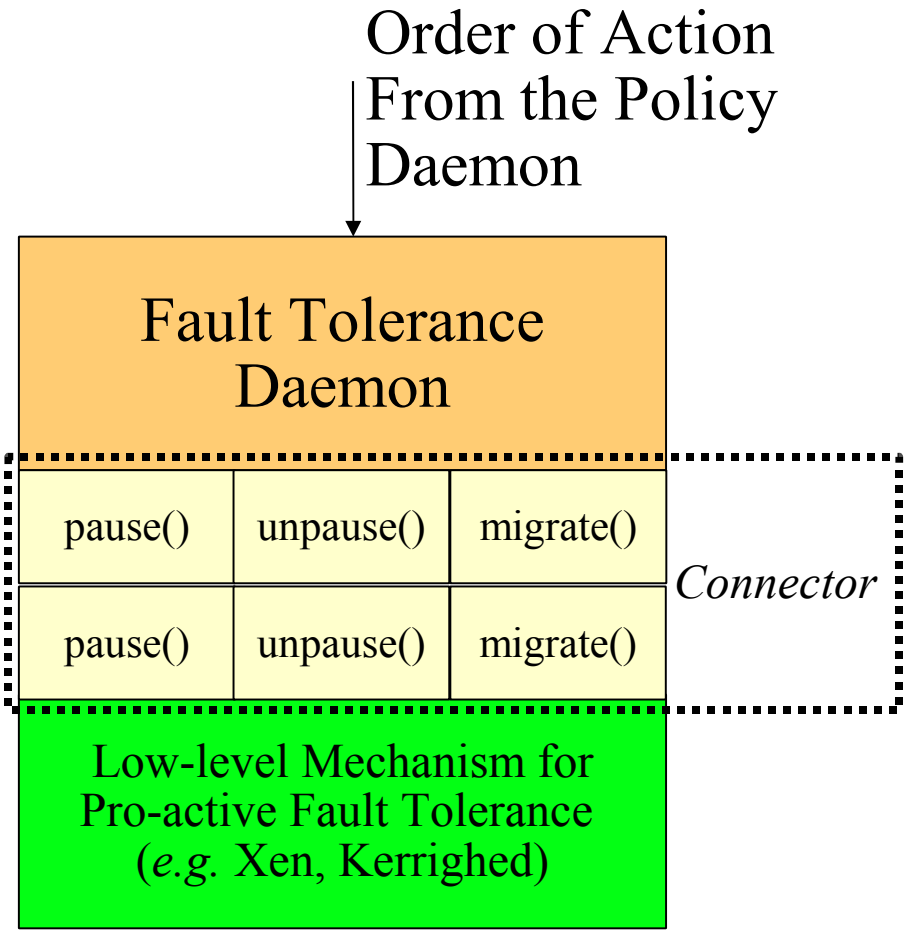
- Implement the proactive FT policy
- Running on the master node
- Receive and analyze alarms sent from *fault predictors*
- If needed, sends an alarm for migration or pause to the compute node

Pro-active FT Framework – Architecture



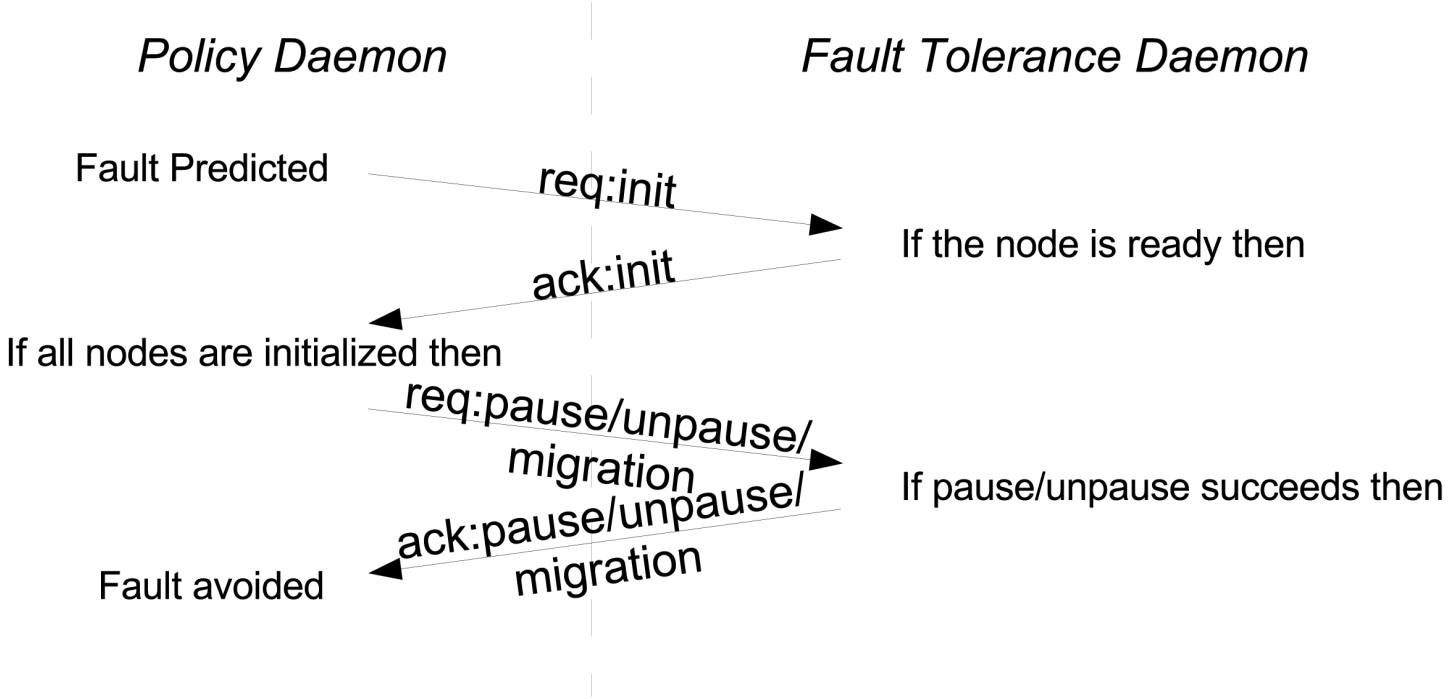
Framework Components – Fault Tolerance Daemon

- Running on the compute nodes
- Abstract the underlying mechanism for migration & pause/unpause (concept of connector)
  - similar to plug-ins
- Receive alarms from policy daemon for migration or pause

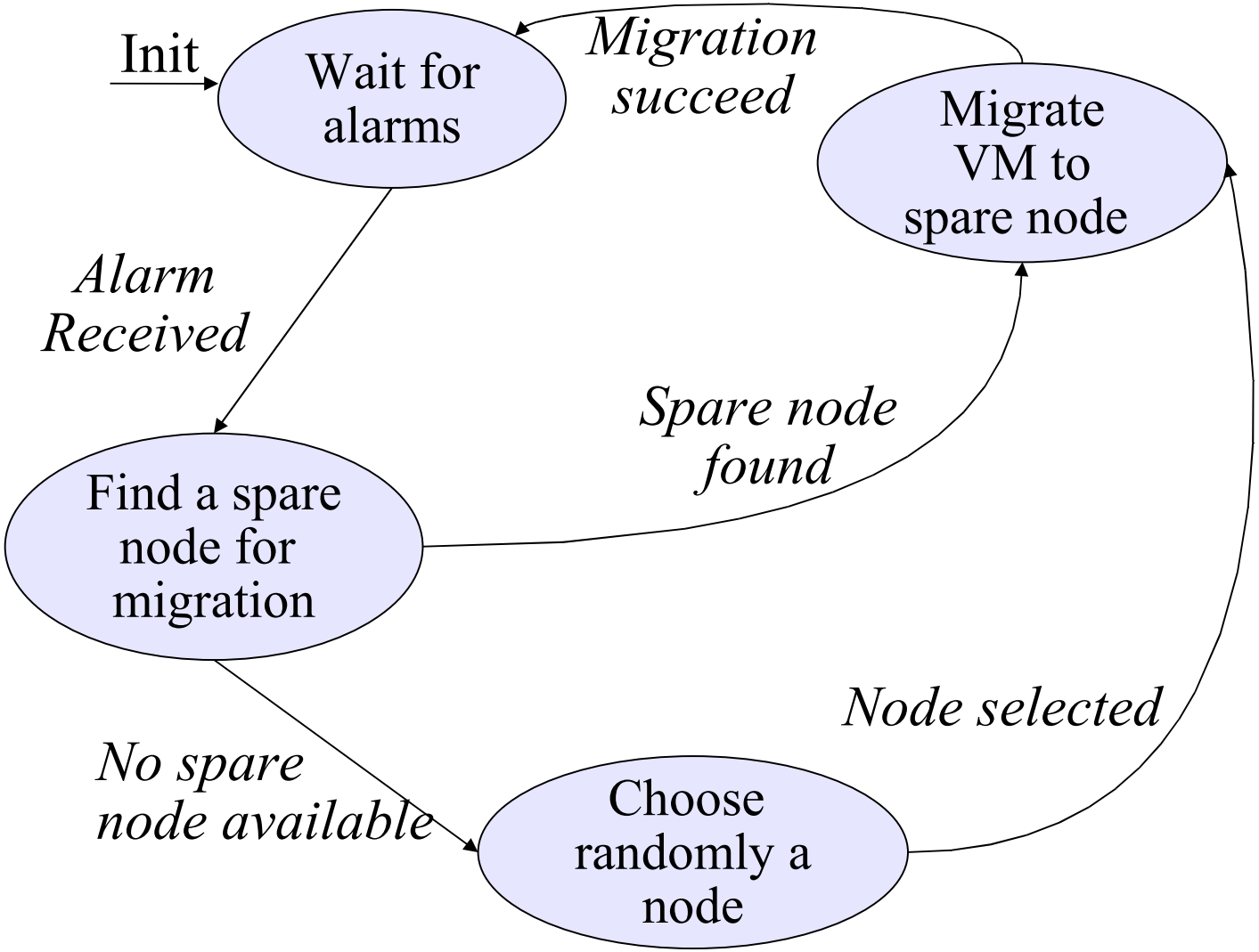


Pro-active FT Framework – Protocol

- **Goal**
  - **guarantee pro-active FT**
  - **detect failures: avoid conflicts between reactive/proactive FT**



Pro-active FT Policy – Example



- ***PS: policy used for evaluation***

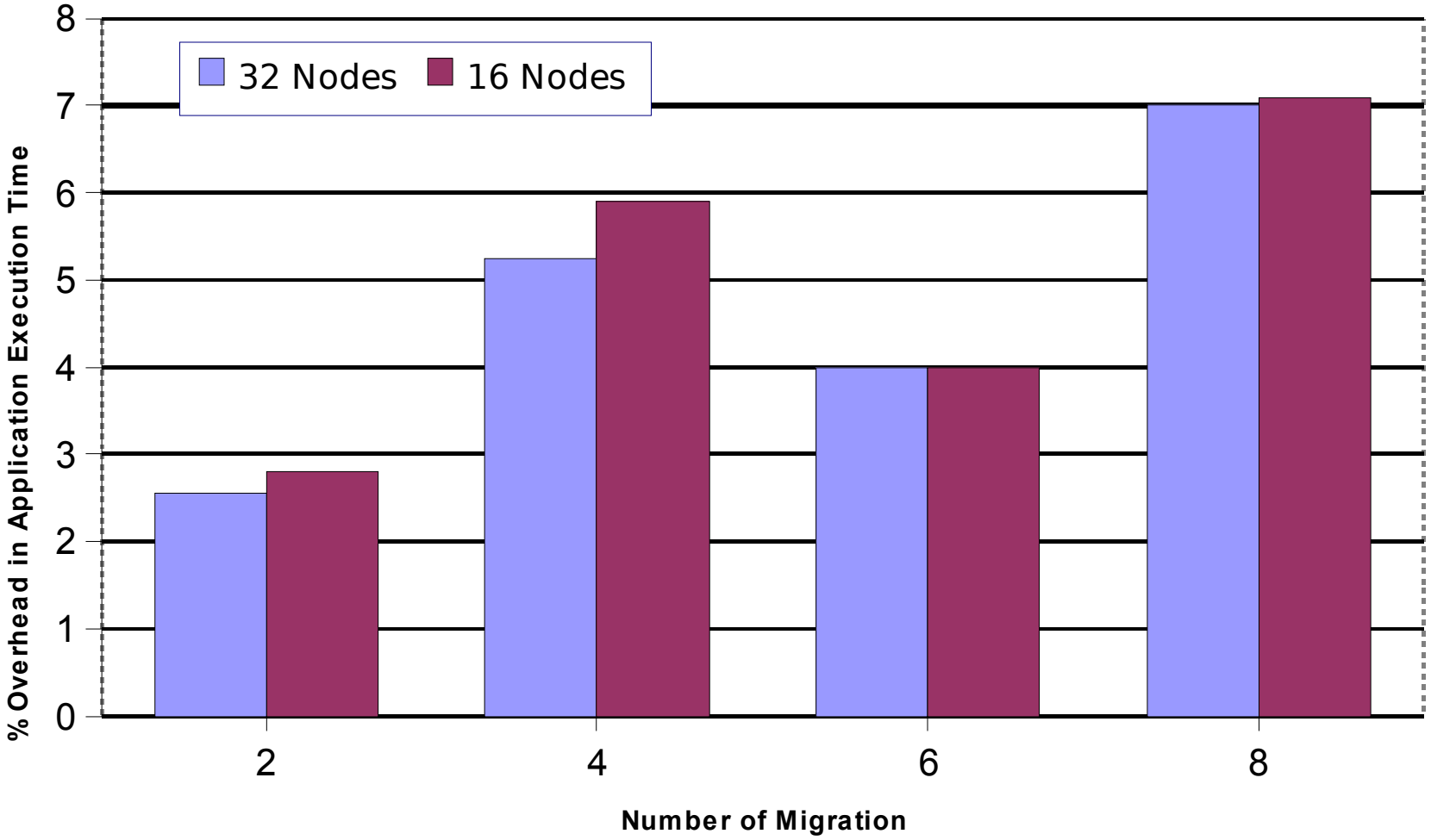
Experimentation Protocol

- 2 sets of experimentations: 16 & 32 nodes
- HPCC benchmark
- We argue that
  - the implementation of multiple policies *cannot* validate the framework (no reference)
  - we can use our simulator as reference
- Policy presented in slide 15
  - users can take benefit of a pool of spare nodes
  - if a alarm is received, we migrate the VM away from the faulty node
    - using a spare node if any available
    - stacking VMs on a random node if no spare node available

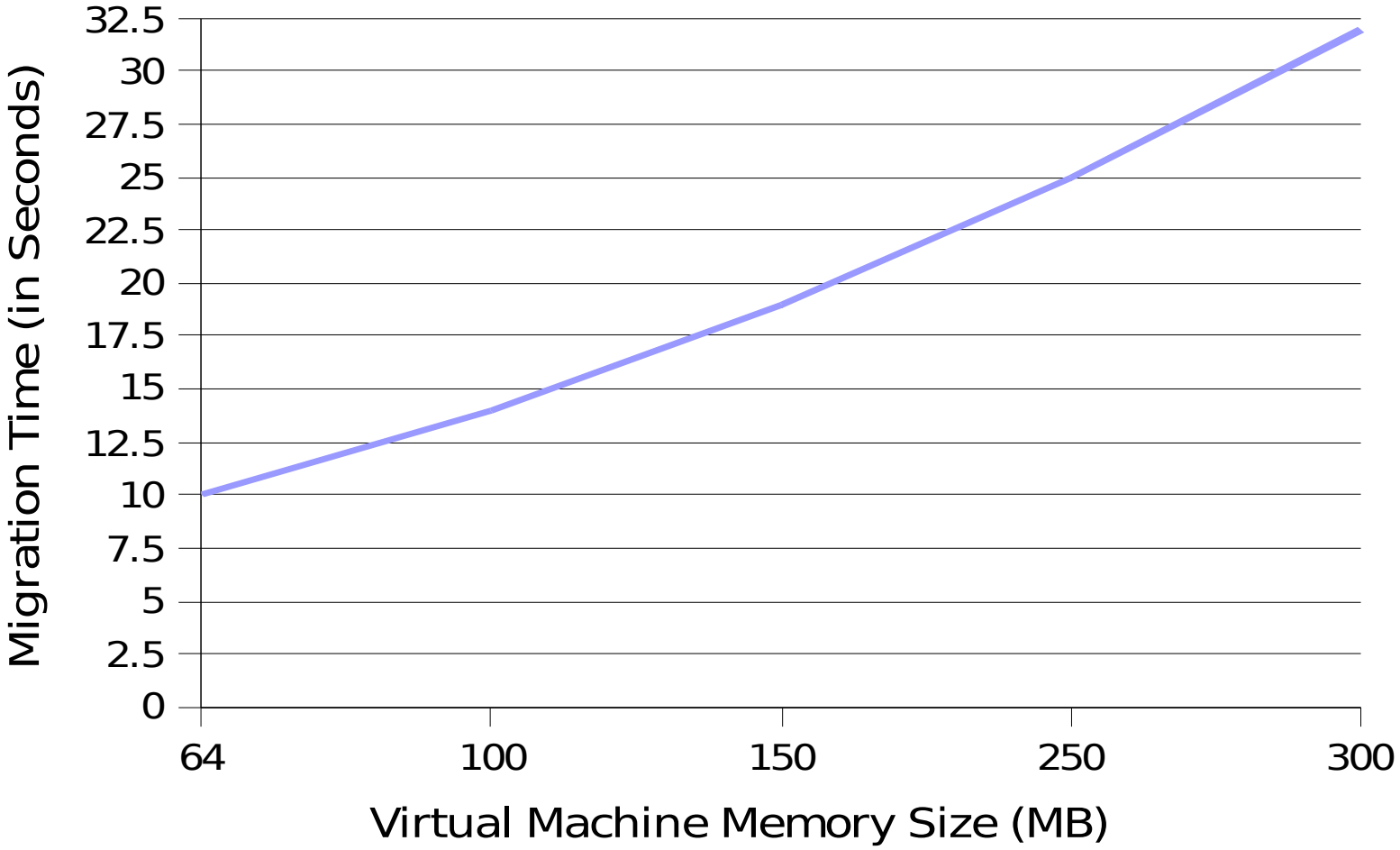
Preliminary Experimentation & Validation

- Comparison w/ our FT simulator
- Experimentation platform
  - based on Xen 3.0.2
  - 40 PIII nodes: HostOS has 200MB of memory; VMs 250 MB
- Simulator characteristics
  - Cluster'07 paper [tiketekar]
  - based on LLNL ASCI White System logs
  - specification of many platform parameters: migration overhead, platform characteristics and so on
  - specify our physical platform characteristics

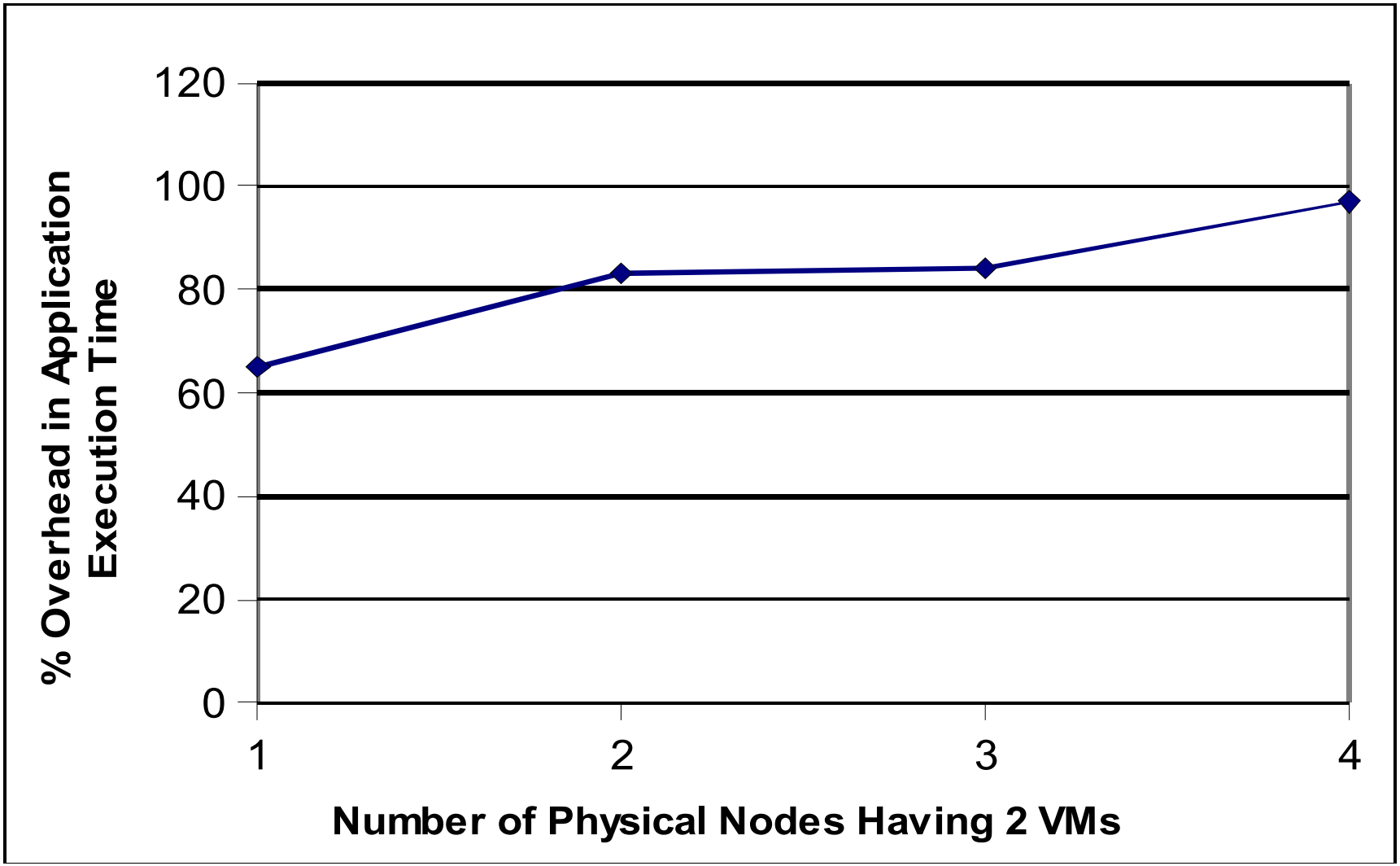
Migration Overhead Evaluation



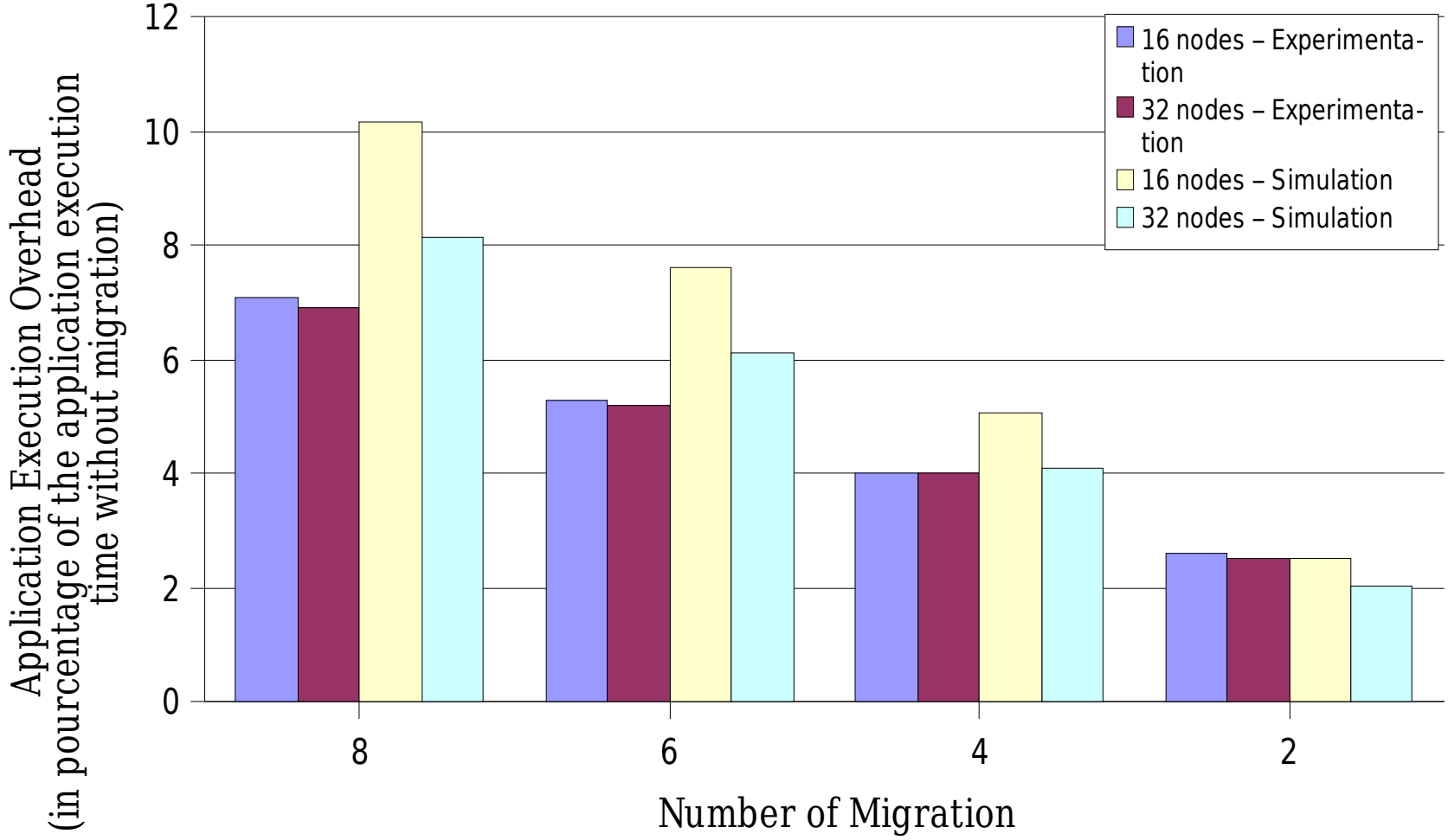
Impact of VM Memory Footprint on VM Migration



VM Stacking Effect



Simulation vs. Experimentation



Conclusion & Future Work

- Proactive FT framework
  - ease the implementation of new pro-active FT policies
  - capable of supporting many different low-level mechanisms
    - virtual machine migration & pause/unpause
    - process-level migration & pause/unpause
  - easily extensible
- Future work
  - reactive FT support
  - integration with scalable communication sub-system
    - Scalable Tool Communication Infrastructure (STCI)

Questions?