**Motivation and Problem**

- Why clouds for HPC
  - Rent vs. own, pay-as-you-go
  - Elastic resources
  - Virtualization benefits – customization, isolation, migration, resource control
- HPC cloud divide
  - Performance vs. resource utilization
  - Dedicated execution vs. multi-tenancy
  - Homogeneity vs. inherent heterogeneity
  - HPC-optimized interconnects vs. commodity and virtualized networks

Mismatch: HPC requirements and cloud characteristics
- Only embarrassingly parallel or small scale HPC applications currently run in clouds

**2. Cost Analysis and Platform Selection**

![Cost Analysis Diagram]

**3. HPC-aware Cloud Schedulers**

- OpenStack cloud on Open Cirrus (KVM as hypervisor)
- HPC Performance (dedicated) vs. cloud utilization (shared)

**3a. Topology, Hardware aware VM placement**

- Network topology - Can significantly improve performance. Why?
  - Centralization - HPC resources; dedicated and shared-mode performance
- Co-location interference: Can significantly improve performance. Why?

**3c. HPC-aware consolidation**

- Dedicated execution for extremely tightly-coupled HPC applications
- For rest, Multi-dimensional Online Bin Packing (MDOBP): Memory, CPU
- Dimension aware heuristics
- Cross application interference aware
- Co-locate apps with complementary execution profile (using 3b)

**Conclusions**

- Cost effective: some HPC applications in cloud not all
- Multiple platforms + intelligent mapping promising
- Significant performance improvement with LB (40%)
- Substantial throughput improvement with application aware consolidation (32%)

**Research Goals and Contributions**

**Goals**

- HPC in cloud

**Techniques**

1. Performance evaluation and analysis
2. Cost analysis and smart platform selection
3. Application aware VM consolidation
4. Heterogeneity, Multi-tenancy aware HPC

**Tools Extended**

- OpenStack Nova Scheduler
- CloudSim Simulator
- Charm++ Load Balancing
- Task Migration

Past research has focused on just the “What” question

**Related Publications**

- A. Gupta et al., “HPC-Aware VM Placement in Infrastructure Clouds,” in IEEE Inf. Conf. on Cloud Engineering (ICCE’13)