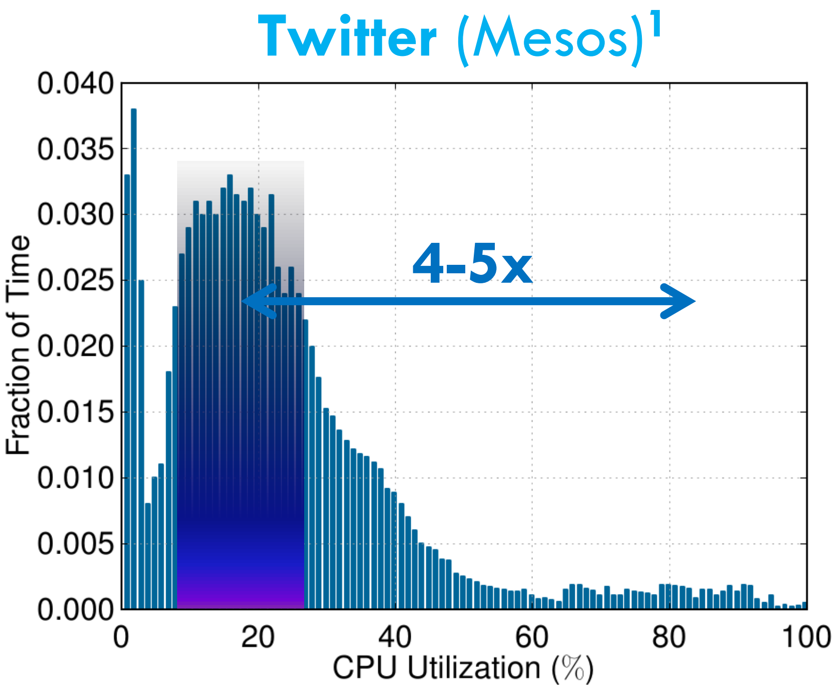
Leveraging Approximation to Improve Resource Efficiency in the Cloud

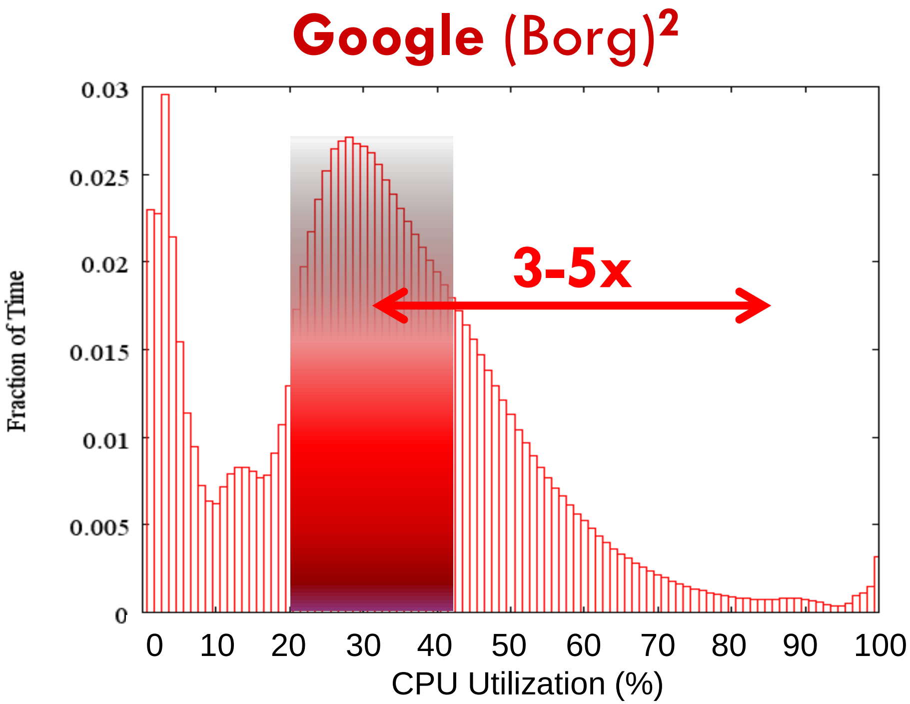
Neeraj Kulkarni, Feng Qi, Glyfina Fernando and Christina Delimitrou

Cornell University

WAX – April 9th 2017

Datacenter Underutilization

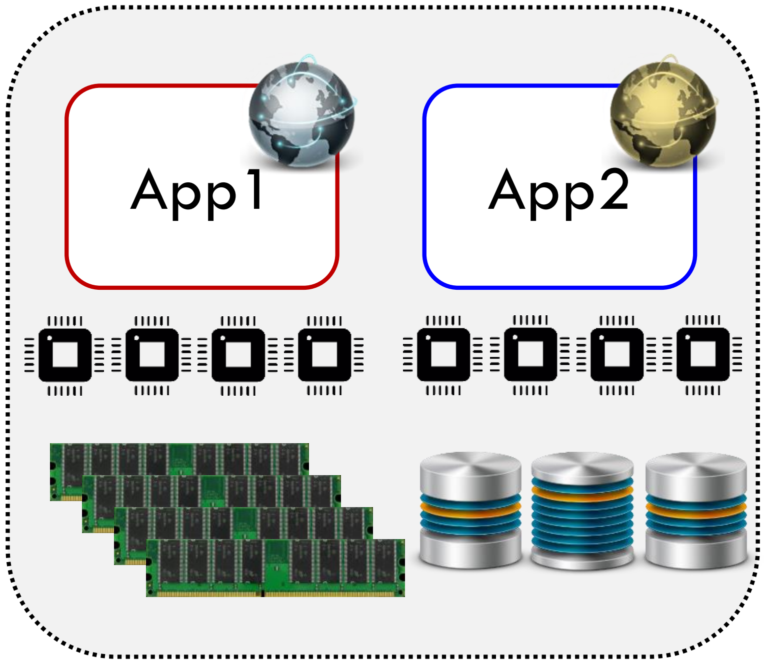




[1] C. Delimitrou and C. Kozyrakis. Quasar: Resource-Efficient and QoS-Aware Cluster Management, ASPLOS 2014.

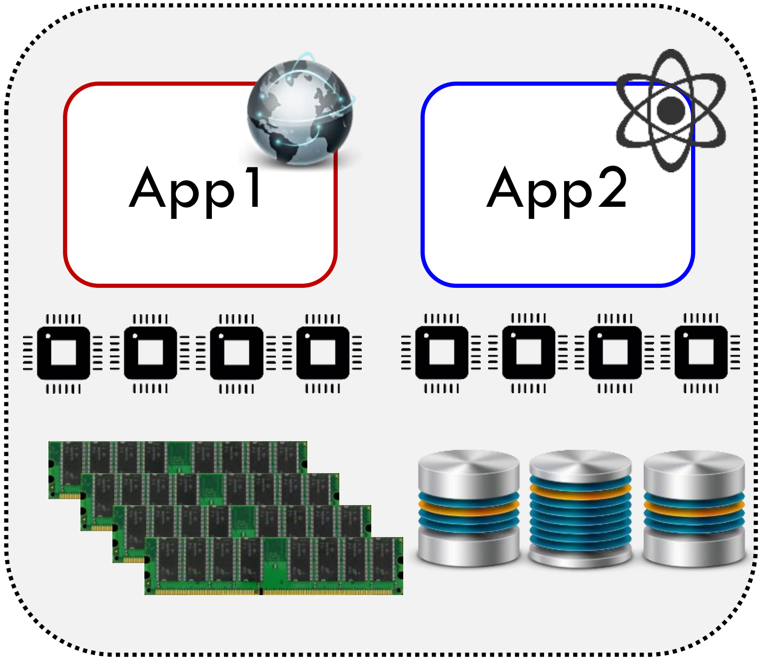
[2] L. A. Barroso, U. Holzle. The Datacenter as a Computer, 2013.

A Common Approach



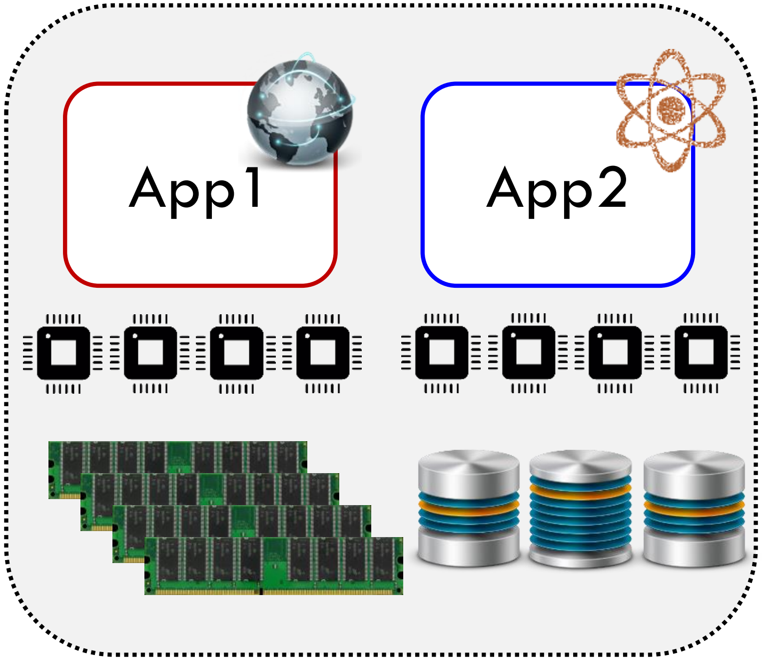
- Co-schedule multiple cloud services on same physical platform
- Often leads to resource interference, especially when sharing cores

A Common Cure



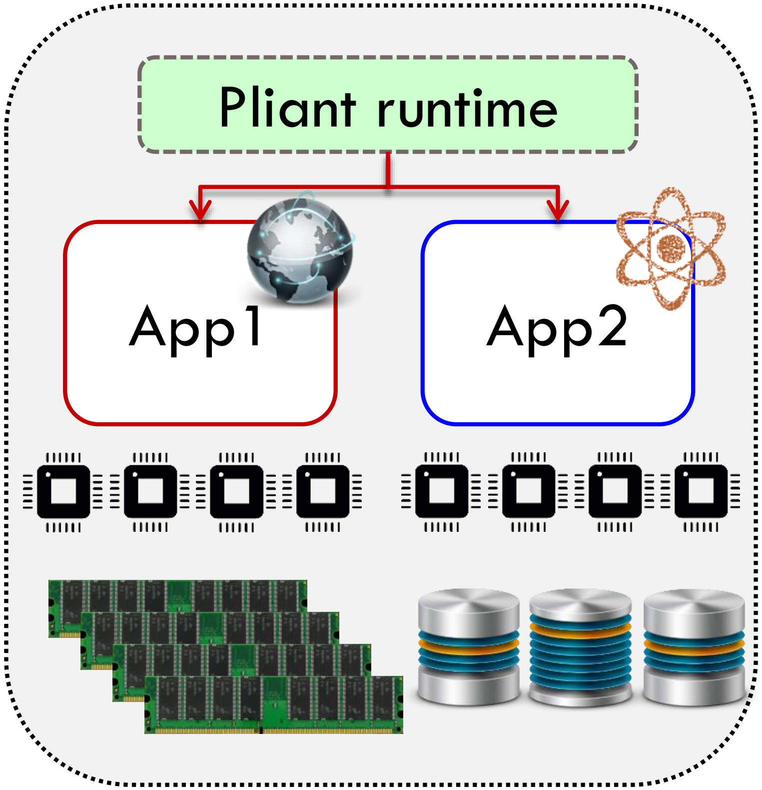
- Co-schedule one high priority and one/more best-effort apps
- Performance is non-critical for best effort jobs
- Disadvantage: assume best-effort apps are always low priority

Approximate Computing Apps to the Rescue



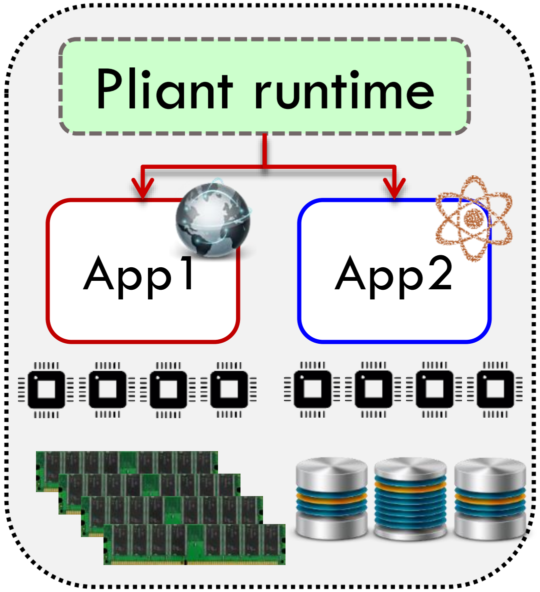
- Approximate computing apps can absorb a loss of resources as loss of output quality instead of a loss in performance
- Advantage: performance of all co-scheduled applications is high-priority

Pliant



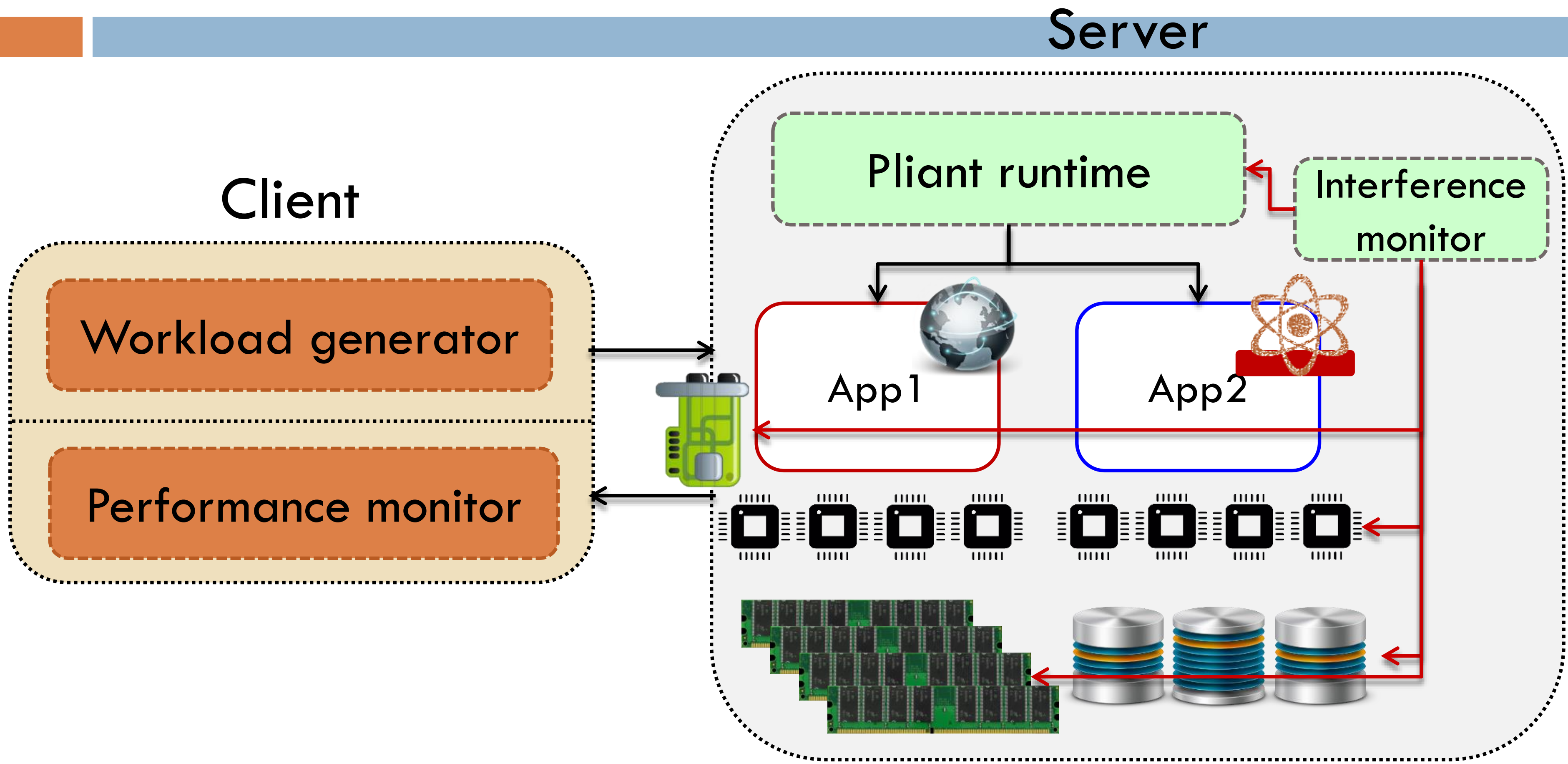
- Enables latency-critical & approximate apps to share resources (including cores) without penalizing their performance
- Tunes degree and type of approximation based on measured interference

Challenges



1. Identify opportunities for approximation
   - ACCEPT (precision, loop perforation, sync elision), algorithmic exploration
2. Lightweight profiling to determine when to employ approximation
   - End-to-end latency/throughput & perf counters
3. Determine what resource(s) to constrain?
   - Based on measured interference
4. Determine what type of approximation & to what extent?
   - Based on interference and performance impact

Pliant



DynamoRIO for switching between precise/approximate versions

- Initial implementation, overheads high but not prohibitive
- Looking into Petabricks and LLVM

Adaptive Approximation

- Incremental approximation:
  - Employ the minimum amount of approximation (quality loss) to restore the performance of the interactive service
  - Several versions for each type of approximation, choose online

- Interference-aware approximation:
  - Choose the type of interference that minimizes pressure in the bottlenecked resource
  - Example:
    - High memory interference → prioritize algo tuning
    - High CPU interference → prioritize sync elision, loop perforation

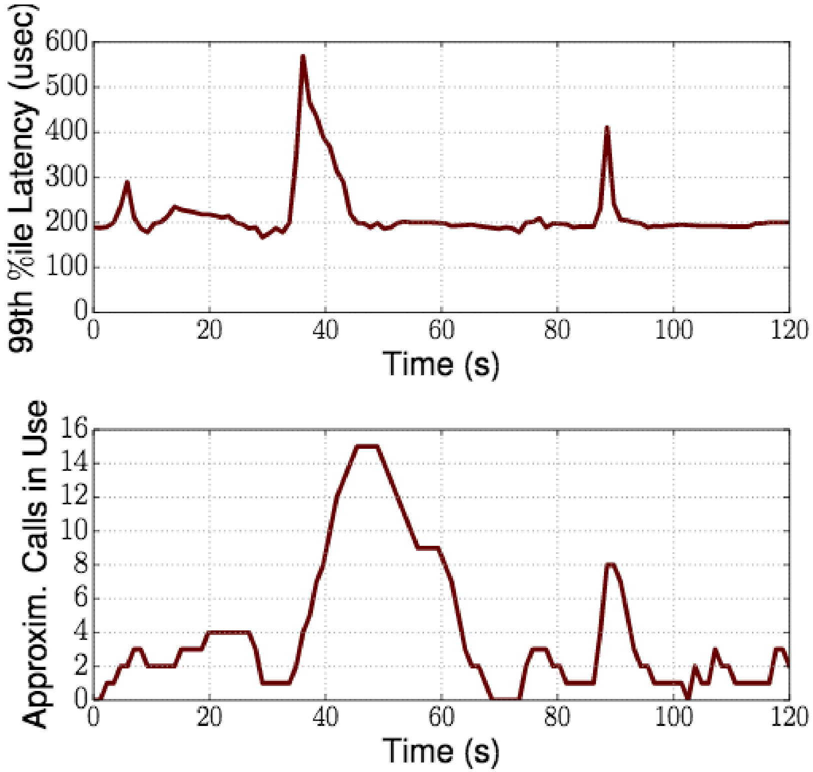
Methodology

- Latency-critical interactive services: memcached & nginx
  - Open-loop workload generator & performance monitor
  - Facebook traffic pattern

- Approximate computing apps: PARSEC, SPLASH, Spark MLlib

- System: 2 2-socket, 40-core servers, 128GB RAM each

Evaluation



- memcached sharing physical cores with PARSEC
- Latency ↑ → Degree of approximation ↑

Conclusions

- Approximate computing: opportunity to improve cloud efficiency without loss in performance
- Pliant: cloud runtime to co-schedule interactive services with approximate computing apps
  - Incremental and interference-aware approximation
  - Preserves QoS for interactive service with minimal loss in quality for approximate computing application

- Current work:
  - DynamoRIO → Petabricks/LLVM
  - Add cloud approximate computing application
  - Improve interference awareness
  - Leverage hardware isolation techniques

Questions?

- Approximate computing: opportunity to improve cloud efficiency without loss in performance
- Pliant: cloud runtime to co-schedule interactive services with approximate computing apps
  - Incremental and interference-aware approximation
  - Preserves QoS for interactive service with minimal loss in quality for approximate computing application
- Current work:
  - DynamoRIO → Petabricks/LLVM
  - Add cloud approximate computing application
  - Improve interference awareness
  - Leverage hardware isolation techniques