CoScale: Coordinating CPU and Memory System 
DVFS in Server Systems

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1. Motivation
- CPU and memory powers dominate
- Many prior CPU DVFS works
- Memory system DVFS was recently introduced
- Uncoordinated DVFS causes poor behavior
- Need coordinated CPU and memory DVFS

2. CoScale
- Mechanisms and OS policy for dynamic energy management
- Lower frequencies to conserve energy within perf. bound
  - DFS the channels, DIMMs, and DRAM
  - DVFS the memory controller (MC) and CPU cores
- How to select the best combination of CPU / memory freqs.?

3. Mechanisms and Policy
- User defines max performance loss
- New performance counters
- OS-level policy leverages counters
  - Profile applications online
  - Pick frequency based on models
  - Per core / memory frequency re-locking
  - Slack update at the end of each epoch
- Low overhead frequency search algorithm

4. Methodology
- Multi-programmed workloads
- 10 mem. freq. between 200 & 800 MHz
- 10 CPU freq. between 2.2GHz & 4.0GHz
- 16 cores and 4 memory channels

5. Results
- Up to 24% energy savings (16% on avg) for 10% perf. bound
- Higher savings than practical approaches; close to offline approach
- Uncoordinated saves significant energy but misses the perf. target
- Paper includes results of various sensitivity studies