Adaptive Scheduling for Systems with Asymmetric Memory Hierarchies

Po-An Tsai, Changping Chen, and Daniel Sanchez
{poantsai, cchen, sanchez}@csail.mit.edu

Background

3D stacking has enabled systems with asymmetric memory hierarchies

Deep hierarchy: Conventional multi-core processors with multi-level cache hierarchy

Shallow hierarchy: Near-data processing cores with shallow hierarchies using few cache levels between cores and memories

Scheduling Applications to the Right Hierarchy is Challenging

Challenge 1: Apps have different preferences

Challenge 2: Preferences change over time

Challenge 3: Preferences change when LLC capacity is contented

AMS: Adaptive Scheduling for Asymmetric Memory Systems

Insight: Modeling a thread’s preferences to different hierarchies bears a strong resemblance to the cache partitioning problem!

AMS overview

Contribution 1: Analytical model to account for asymmetries

Contribution 2: Two thread placement algorithms that extend techniques originally designed for cache partitioning

1. AMS-Greedy

2. AMS-DP

Evaluation

1. Methodology:
   8-core processor die; 3-level deep hierarchy with 16MB shared LLC
   4 NDP stacks; 2 cores per stack; 2-level private-cache-only shallow hierarchy

2. Multi-programmed results

   AMS-Greedy finds the right hierarchy for each application. It never hurts performance and improves weighted speedup by up to 37% and by 18% on average over the Random baseline.

3. Multi-threaded results

   AMS also handles multithreaded workloads under asymmetric hierarchies, improving gmean performance by 22% over the Random baseline.

See the paper [https://goo.gl/3yDmK] for more results: case study of AMS adapting to phases, comparison with prior contention- and core-asymmetry-aware schedulers.