Imbalanced Cache Partitioning for Balanced Data-Parallel Programs

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Contributions

- Shared last-level cache partitioning for balanced data-parallel applications
- Balanced allocation is suboptimal for balanced programs
- Increasing allocation for one thread at a time improves utilization
- High imbalance helps both preferred and un-preferred threads
  - ➢ Preferred thread benefits because working set now fits into partition
  - ➢ Un-preferred threads benefit by using the data left behind in the preferred partition
- Prioritizing each thread in turn ensures balanced progress
- 17% drop in miss rate, 8% drop in execution time on average for 4-core 8MB cache
- Negligible overheads

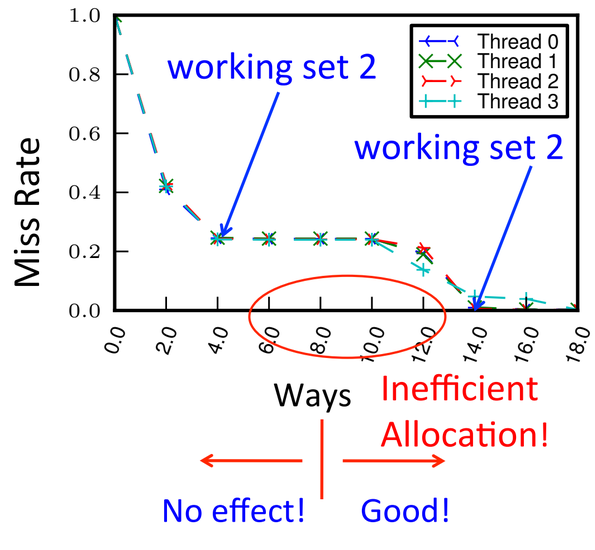
Motivation

Last level cache partitioning heavily studied for multiprogramming workloads

Multithreading different than multiprogramming

- ➢ All threads have to progress equally
- ➢ Pure throughput maximization is not enough
- ➢ Data-parallel threads are similar to each other in their data access patterns

Only way to improve utilization is through imbalance in allocation

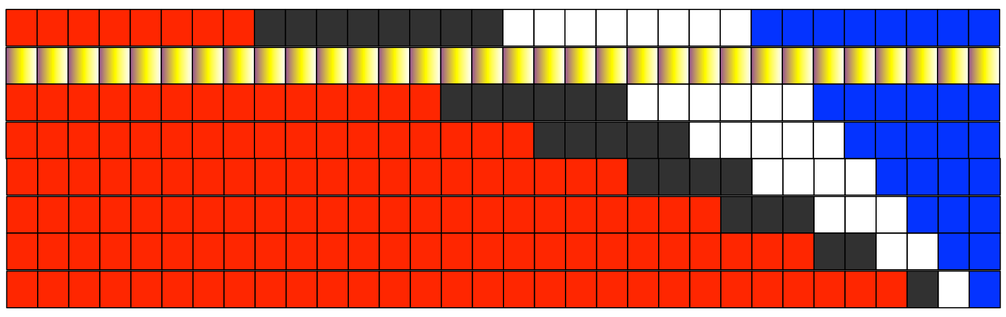


Preferred thread benefits since increased allocation covers working set

Un-preferred thread benefits from data remaining in preferred partition

Method

2-Stage Partitioning



Thread 1 Thread 2 Thread 3 Thread 4 No partitions

Evaluation Stage

- ➢ Triggers at the start of a new program phase
- ➢ Divide the cache sets into equal-sized segment
- ➢ Each segment with a different level of imbalance
- ➢ A segment for un-partitioned cache
- ➢ Each core is prioritized in turn
- ➢ Select configuration with least number of misses

Stable Stage

- ➢ Maintain the chosen configuration till the next program phase change
- ➢ Choose preferred thread in round-robin manner

Evaluation

4-core CMP with 32 way shared L2, 9 data-parallel workloads from PARSEC AND SPEC OMP suites

Baselines

- ➢ Compared to a statically equi-partitioned cache and a CPI-based adaptive partitioning scheme
- ➢ Misses and execution time normalized to an un-partitioned cache

Overheads

- ➢ Per-segment way partitioning and counters
- ➢ Program phase detection
- ➢ Evaluation stage overhead for small cache (1 % ave., 5 % max.)

Conclusion

Effective cache utilization and balanced progress for data-parallel applications through:

A. High Imbalance in partitions and
B. Prioritizing each thread in turn

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