DAOS: Data Access-aware Operating System

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Abstract

In data-intensive workloads, data placement and memory management are inherently difficult: the programmer and the operating system have to choose between (combinations of) DRAM and storage, replacement policies, as well as paging sizes. Efficient memory management is based on fine-grained data access patterns driving placement decisions. Current solutions in this space cannot be applied to general workloads and on production systems due to either unrealistic assumptions or prohibitive monitoring overheads.

To overcome these issues, we introduce DAOS, an open-source system for general data access-aware memory management. DAOS provides a data access monitoring framework that utilizes practical best-effort trade-offs between overhead and accuracy. The memory management engine of DAOS allows users to implement their access-aware management with no code, just simple configuration schemes. For system administrators, DAOS provides a runtime system that auto tunes the schemes for user-defined objectives in a finite time. We evaluated DAOS on commercial service production systems as well as state-of-the-art benchmarks. DAOS achieves up to 12% performance improvement and 91% memory saving. DAOS is open-sourced and available in the Linux kernel.

We Need Data Access-aware Operating System

- Because DAOS can predict future memory usage better
- Because it helps making better data management decisions
- Because it can improve memory efficiency and performance
- Because DRAM is a major infrastructure expense

DAOS: DAMON-based Operation Schemes

- DAMON-based memory management schemes engine for DAOS
- Receives ‘schemes’: each scheme is constructed with
  - Target access pattern: ranges of size, access frequency, and age
  - 1 memory management action
- Currently supported actions include: WILLNEED, SWAP, PAGEOUT, HUGEPAGE, NOHUGEPAGE
- DAMOS automatically finds the memory region of the target pattern from DAMON results and applies the action to the region
- Now users can make DAMON-based optimizations with no-code

DAMOS: DAMON-based Optimal Operation Schemes (Auto-tuning Runtime for DAOS)

Simplifying The Problem

- We care only memory efficiency and performance at last
  - These can be consolidated into one metric (score) with different priorities
  - Giving the priorities could be easy for users (depends on users’ SLO)
- The target access pattern is only the aggressiveness of the scheme
- The multi-dimension search space can be reduced to 2-dimension
  - Aggressiveness as X-axis, Score as Y-axis
- We can further expect six simple patterns in common cases

Sampling

- Calculate how many times we can measure the score for different
  - The user-specified tuning time divided by the unit work time
- Run the workload with 60% of ‘nr_samples’ schemes having random aggressiveness and measure one score for each scheme
- Run the workload with 40% of ‘nr_samples’ schemes having random but near to the best of the 60% sample results aggressiveness

Estimation and Selection

- Find the relationship between the aggressiveness and score by applying Polynomial curve fitting to the ‘nr_samples’ data points
- On the curve, we find an aggressiveness value that generates maximum score and use it as the best scheme aggressiveness

DAOS is OpenSource

- Kernel parts of DAOS are merged in the Linux; User-space parts of DAOS are available at https://github.com/damonitor
- Visit https://damonitor.github.io for quick start