Lifetime Management of Flash-Based SSDs Using Recovery-Aware Dynamic Throttling

Sungjin Lee, Taejin Kim, Kyungho Kim†, and Jihong Kim
Seoul National University †Samsung Electronics

Motivation

• The poor write endurance of SSDs is a main barrier for wider adoption of SSDs in the enterprise market.
• The endurance of SSDs is rapidly decreasing.
  – 100K P/E cycles (SLC) → 3K P/E cycles (2x nm MLC)
  (Source: Jmicron, Western Digital, Morgan Stanley Research)
• The lifetime of SSDs is unpredictable.
  – The SSD lifetime is determined by write intensiveness of a workload (i.e., the amount of data written by a workload).
• It is a challenge to guarantee the required SSD lifetime, which is important for enterprise customers.

Our Approach

• Guarantee the required SSD lifetime by throttling (or reducing) the write performance of the SSD
• Static throttling (existing approach)
  – Limit the maximum SSD bandwidth to a certain fixed value
  – Underutilize the maximum endurance of the SSD
• Dynamic throttling (our approach)
  – Throttle the SSD performance adapting to a workload
  – Fully utilize the maximum endurance of the SSD, offering better performance than static throttling

Recovery-aware Dynamic Throttling (READY)

• Self-recovery effect: the number of effective P/E cycles is much larger than the number on datasheets.
• Recovery-aware dynamic throttling (READY): exploit the self-recovery effect to guarantee the SSD lifetime with less throttling overheads

Dynamic Throttling

• Determine a throttling delay as low as possible
• Distribute a throttling delay over every write request as evenly as possible

Results

• Evaluate the lifetime and performance using enterprise traces from MSR-Cambridge and MS-Production
• Guarantee the 5-year lifetime for all the traces
• Improve the write speed by 4x over static throttling