Overcoming Capacitance Constraints in SSD

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Abstract

The growth in SSD capacity is reaching its limit due to the stunted growth of capacitors—electrical components that store charge to protect data for the volatile memory in case of power loss. This paper presents `Dawid`, a novel SSD-internal DRAM management scheme that allows the SSD capacity to scale beyond the slow growth of capacitors. `Dawid` suppresses an increase of the dirty memory footprint within buffer using the deep queues available in today's storage interfaces. We implement our design in `FEMU`, an open-source SSD development framework and demonstrate that `Dawid` delivers IOPS close to 90% of performance at only 1% of capacitance compared to the existing scheme.

1 Introduction

The SSD has increased significantly in density for the past decade. In 2011, a typical 2.5-inch SSD had 256GB capacity, but by 2018, a high-capacity SSD boasted a 30TB, expanding by 100× over the past ten years [1, 7]. This remarkable growth of the device-capacity is thanks to the advanced scaling technologies such as nanoscale fabrication [**?**] and multi-layer stacking [**?**].

The enterprise-class SSDs adopt the capacitor to protect data for volatile buffer in case of power crash. SSD-internal buffer is used for buffering user writes and caching translation information (also known as mapping table). If they are not protected, SSDs will have not only a data loss and/or corruption but also a long recovery time to build an up-to-date mapping table by scanning entire flash drives. To prevent this unwanted situation, enterprise-class SSDs rely on the capacitors that persist data of the volatile buffer in a power loss using a reserved energy.

However, the reliance on capacitors is no longer sustainable as the increase in SSD far outpaces the increase in capacitor density. Al(aluminum) and Ta(tantalum)-electrolytic capacitors used in SSDs have increased in density by tenfold from 1960 to 2005. This is approximately 50x slower than the SSD density increase rate. Because the internal buffer size increases in proportion to the storage capacity (typically 0.1% of storage capacity [6, 8]), the density gap between capacitance and memory technologies imposes an intrinsic limitation on the current architecture wherein the entire buffer is fully protected by capacitors.

This paper presents a device-internal buffer architecture called `Dawid` for the SSDs under capacitance constraints.

- Eviction policy : 맵핑 테이블의 일부만 보호되고 있을 때 보호범위를 넘어서면 더티 엔트리를 플러쉬 해야 함.
- Re-ordering policy
- Flush policy

The data maintained in the buffer can be classified into two types: the actual user data and the metadata for SSD management (i.e, mapping table). When the buffer is partially protected, the number of dirty pages is limited to the maximum amount of data that the on-board capacitance can protect. If the number of dirty pages goes beyond the limit, changes should be flushed to the flash memory immediately to meet the durability constraint for SSDs.

References

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