Abstract

We propose a storage platform that will allow users to quickly and easily create systems of arbitrary storage devices that can be accessed through an API. Many new storage technologies have been introduced in recent years, but configuring them to interact intelligently with other storage devices currently requires writing custom software to specify their interactions. Our proposed platform will instead offer users a simple, declarative language in which to define arbitrary custom storage device configurations. My contributions to this larger platform will be twofold. First, I will aid in researching and designing the structure of the final platform, as well as discovering new devices to support on the platform. Second, I will implement the operations that the platform can perform on and between storage devices.

Motivation

In recent years, we have witnessed the introduction and proliferation of many new storage technologies, each presenting a unique set of strengths and weaknesses. For instance, the use of SSDs is becoming more commonplace as their cost continues to drop, and shingled magnetic recording (SMR) technology offers significantly higher bit density on HDDs than was previously possible. However, SSDs suffer from lower mean time to failure than HDDs because of the limit on block erasures that can be performed
on NAND flash storage devices. On the other hand, SMR HDDs are con-
strained to sequential writes because of the way in which magnetic tracks
are placed on disk. Rather than space out tracks as conventional HDDs do,
SMR HDDs lay down tracks with an overlap, increasing bit density at the
cost of preventing updates to a sector of a track that is already overlapped
by another.

Existing storage hardware can be leveraged to improve the performance
of these new technologies. For instance, using a conventional HDD as a
sequential write cache for an SSD can improve the lifetime of an SSD by
a factor of two [1]. Many similar configurations of storage devices could
result in general performance improvements or traits that are desirable for
particular workloads, but writing custom software to define each configura-
tion is time-consuming and inherently inflexible. Thus, creating and testing
a large number of new storage configurations is currently infeasible.

Our proposed platform will enable the creation of novel storage device
configurations without writing custom code to define the operations be-
tween storage devices, which will in turn enable modeling and testing the
performance of new storage configurations. This also opens up the pos-
sibility of automatically discovering configurations that exhibit desirable
characteristics.

Design

The platform’s hardware will consist of a set of storage devices attached
to a machine. The machine will expose an API that allows other machines
to perform operations on the attached storage devices. The relationships
amongst the attached storage devices can be represented by a tree, where
the leaf nodes are storage devices, the intermediate nodes are operations
performed on their descendant leaf nodes, and the root node is the exposed
API.

The platform’s software will primarily consist of three components:

1. A **declarative language** in which users can define storage device con-
figurations

2. An **automatic code generator** that will transform a tree of devices and
operators (expressed in the aforementioned declarative language) into
code that performs those operations on devices

3. An API that allows machines to perform operations on the attached storage devices

**Project Scope**

Creating the entirety of the described platform will likely constitute a multi-year endeavor. Here I will explain the scope of my personal contributions to the platform and the deliverables I plan to provide by the end of the term.

My contributions to the project can be broken down into two categories:

1. I will aid in researching and designing the final structure of the platform, as well as discovering new devices to support on the platform.
2. I will implement the operations that the platform can perform on and between storage devices.

My deliverables follow the form of these contributions:

1. A **project report** describing the research that I performed in order to arrive at a final design for the platform, as well as a detailed description of the storage platform
2. The **source code and compiled program** that implement the aforementioned operations

**References**

1. S. Soundararajan, V. Prabhakaran, M. Balakrishnan, T. Wobber, in *Extending SSD Lifetimes with Disk-Based Write Caches*, University of Toronto and Microsoft Research Silicon Valley. (Available via Usenix, 2010)