Poster Submission: Analysis of Workload Behavior in Scientific and Historical Long-Term Data Repositories

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Abstract

The traditional view of archival storage as simply cheap tertiary storage or backup is obsolete. Recent years have seen an explosion of long term storage use-cases, ranging from business and medical record compliance, to publicly viewable historical and scientific content archives. Despite this rapid growth, there are no up-to-date studies of modern archival storage systems; the most recent studies were on the tertiary storage systems of supercomputers nearly 2 decades ago. Because of this lack of timely information, system designers are forced to rely on anecdotes and conjecture in their designs.

We endeavor to begin closing this knowledge gap by providing up-to-date system characteristics and access behavior data to help guide the design of future archival systems. We have examined several systems from a variety of archival use-cases and found significant breadth in the characteristics and behavior of modern long-term storage systems. We discovered that tertiary storage systems appear to be becoming more disk-centric as disk prices continue to drop, though interestingly aggregate modification behavior appears similar to that of 2 decades ago. We additionally found that the oft held assumption of write-once, read-maybe does not hold universally, as internal and external administrative processes frequently read, and even modify archival data, often en masse. This suggests the use of a separate asynchronous batch interface for large scale accesses, allowing for tight control of otherwise disruptive accesses. This can yield aggregate performance and energy efficiency improvements overall as large accesses will be able to be optimally scheduled more easily. We also found that while individual users show strong content preferences, that is they frequently only accessed a limited number of data types, system wide there was little in the way of popular content. This suggests that simply grouping data based on semantic content may prove fruitful in some cases, while fine granularity access prediction and file migration may be quite difficult due to the very modest skew in per-file and record popularity.

We also discovered that acquiring useful datasets proved to be extremely challenging. The worst examples we encountered were logs with no field descriptions or supporting documentation, making them effectively unusable. Even with significant—and much appreciated—help from system architects and administrators much data was still unusable. Seemingly trivial actions such as file renaming, led to extreme difficulties in identifying update patterns as we could not effectively map updates to the correct file for its entire lifetime. This problem is compounded only compounded in long-term tracing in archival systems. In contrast to storage systems such as those used in enterprise and the desktop, traces *must* be gathered over years. If data are not gathered properly, reacquiring a trace can take years, perhaps preventing the trace from driving an analysis to guide the design of the archival storage system's successor. In addition, there is a need for consistent tracing standards to ensure ease of use and readability far into the future.

To this end, we see a need for *data-centric* tools for long-term tracing that would be useful for a variety of reasons. First, seemingly trivial actions can make analysis of longer-term trends extremely difficult, such as the file renaming issue mentioned above. Second, as systems become increasingly distributed, there maybe multiple instances of the same corpus in a single system, motivating the need for tracing tools that can provide a holistic view across archives. Third, given the intended long lifetime of many corpora, data will live on many systems over its life. In order to understand how data behavior evolves, a long-term trace must extend beyond the lifetime of any single system.

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