A Dynamic Multi-Tiered Storage System for Extreme Scale Computing
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ABSTRACT

In the era of data explosion, where data analysis is essential for scientific discoveries, the slow storage system has led to the research community known as I/O bottleneck. Additionally, the explosion of data has led to proliferation of applications as well as storage technologies. This has created a complex matching problem between diverse application requirements and storage technology features. In this paper, we introduce Jal, a dynamic, re-configurable, and heterogeneous-aware storage system. Jal utilizes a layered approach including application model, data model, and storage model. Our evaluations have shown these models, can accelerate I/O for the application while transparently and efficiently utilizing the diverse storage systems.

CHALLENGES

Challenge 1: How to understand and characterize the cause of application I/O behavior?
Understanding the application’s I/O behavior is cumbersome and the research has been focused on understanding “How Happened”. However, they have to provide manual analysis and heuristics to determine its causal relationship for the observed I/O behavior.

Challenge 2: How to match diverse application requirements with storage configurations?
Scientific workflows require a diverse set of performance requirements to perform I/O. However, modern storage system are not re-configurable to adapt to conflicting I/O requirements and complex heterogeneous storage hierarchy.

Challenge 3: How to design a dynamically re-configurable multi-tiered storage system?
Modern system are multi-tier and run a variety of workflows that have multiple conflicting requirements. However, software stack is designed for static, homogeneous and fixed software deployments and fail to cope in this dynamic environment.

HIGH-LEVEL DESIGN

Jal storage system is a dynamic re-configurable multi-tiered storage system which can achieve perfect matching between application requirements and diverse storage technologies.

- Application Model using Vidya: It uses a source-code based profiler which identifies the cause of the I/O behavior of applications. Using this approach, Vidya can enable automated optimization and insights on application I/O behavior.
- Storage Model using ChronoLog: It builds a heterogeneous-aware storage system which can be dynamically re-configured to different storage configurations during runtime.
- Data Model using Optimization: Each optimization translates different application’s I/O requirements into underlying storage configuration to extract maximum performance of each applications. We develop novel data compression, data prefetching, and data replication engine that can transform different application requirements into storage configuration for optimizing I/O.

CONCLUSIONS

We presented Jal storage system, a dynamic, multi-tiered storage system which can be reconfigured for different application requirement on runtime. We discussed our layered methodology along with of extracting application requirements, converting them into various storage configuration, and finally a building a mallable log storage which can deploy these storage configurations. We showcased through evaluations that this approach can lead to 7x better performance over existing storage systems by utilizing several automated layers of source-code based profiler, data access optimizations, and a distributed log storage. Additionally, we showcased that this approach is viable for modern multi-tiered super computers with good performance benefits.

PAPERS