

A Load Balancing Framework for Clustered Storage Systems

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Abstract. The load balancing framework for high-performance clustered storage systems presented in this paper provides a general method for reconfiguring a system facing dynamic workload changes. It simultaneously balances load and minimizes the cost of reconfiguration. It can be used for automatic reconfiguration or to present an administrator with a range of (near) optimal reconfiguration options, allowing a tradeoff between load distribution and reconfiguration cost. The framework supports a wide range of measures for load imbalance and reconfiguration cost, as well as several optimization techniques. The effectiveness of this framework is demonstrated by balancing the workload on a NetApp Data ONTAP GX system, a commercial scale-out clustered NFS server implementation. The evaluation scenario considers consolidating two real world systems, with hundreds of users each: a six-node clustered storage system supporting engineering workloads and a legacy system supporting three email servers.

1 Introduction

The basic premise of clustered storage systems is to offer fine-grained incremental capacity expansion and cost-effective management with performance that scales well with the number of clients and workloads [1,2,3,4,5,6]. To address load imbalance, most previously proposed architectures either dynamically redistribute individual data objects and hence load among individual nodes in response to changing workloads [2,5], or use algorithmic approaches for randomized data allocation (e.g., variants of linear hashing [7]) to distribute workload across cluster nodes [4,6].

However, the first approach is not well suited for enterprise storage systems. First, deployed systems typically collect only cumulative statistics over a period of time [8,9], as opposed to detailed traces with per-request timings [10,11]. Yet, systems with data migration at the level of individual objects [2,5] typically use techniques that require detailed traces to make informed decisions [12]. Second, workloads do not always change gradually. They often do so in distinct steps, for example, during consolidation when an existing system inherits a legacy system workload.

A complementary approach to balancing load across system components is to use offline solvers [8,13]. They typically use a variant of the bin-packing or knapsack problem [14] to find a cost-efficient system configuration (solution). They require only a high-level workload description [15] and capacity or performance system model. While such solvers have been shown to be effective for building an enterprise-scale system from the ground up, they are less suitable when already deployed systems grow or experience workload changes over time. Previous work proposed to iteratively apply

A Load Balancing Framework For Clustered Storage Systems

Zhe Xu



A Load Balancing Framework For Clustered Storage Systems:

The book delves into A Load Balancing Framework For Clustered Storage Systems. A Load Balancing Framework For Clustered Storage Systems is a crucial topic that needs to be grasped by everyone, ranging from students and scholars to the general public. This book will furnish comprehensive and in-depth insights into A Load Balancing Framework For Clustered Storage Systems, encompassing both the fundamentals and more intricate discussions.

1. This book is structured into several chapters, namely:
 - Chapter 1: Introduction to A Load Balancing Framework For Clustered Storage Systems
 - Chapter 2: Essential Elements of A Load Balancing Framework For Clustered Storage Systems
 - Chapter 3: A Load Balancing Framework For Clustered Storage Systems in Everyday Life
 - Chapter 4: A Load Balancing Framework For Clustered Storage Systems in Specific Contexts
 - Chapter 5: Conclusion
 2. In chapter 1, the author will provide an overview of A Load Balancing Framework For Clustered Storage Systems. This chapter will explore what A Load Balancing Framework For Clustered Storage Systems is, why A Load Balancing Framework For Clustered Storage Systems is vital, and how to effectively learn about A Load Balancing Framework For Clustered Storage Systems.
 3. In chapter 2, this book will delve into the foundational concepts of A Load Balancing Framework For Clustered Storage Systems. The second chapter will elucidate the essential principles that must be understood to grasp A Load Balancing Framework For Clustered Storage Systems in its entirety.
 4. In chapter 3, the author will examine the practical applications of A Load Balancing Framework For Clustered Storage Systems in daily life. This chapter will showcase real-world examples of how A Load Balancing Framework For Clustered Storage Systems can be effectively utilized in everyday scenarios.
 5. In chapter 4, this book will scrutinize the relevance of A Load Balancing Framework For Clustered Storage Systems in specific contexts. This chapter will explore how A Load Balancing Framework For Clustered Storage Systems is applied in specialized fields, such as education, business, and technology.
 6. In chapter 5, the author will draw a conclusion about A Load Balancing Framework For Clustered Storage Systems. The final chapter will summarize the key points that have been discussed throughout the book.
- The book is crafted in an easy-to-understand language and is complemented by engaging illustrations. It is highly recommended for anyone seeking to gain a comprehensive understanding of A Load Balancing Framework For Clustered Storage Systems.

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