**LITERATURE SURVEY**

**1) iDedup: Latency-aware, Inline Data Deduplication for Primary Storage**

**Authors:** K. Srinivasan, T. Bisson, G. Goodson, and K. Voruganti

Deduplication technologies are increasingly being deployed to reduce cost and increase space-efficiency in corporate data centers. However, prior research has not applied deduplication techniques inline to the request path for latency sensitive, primary workloads. This is primarily due to the extra latency these techniques introduce. Inherently, deduplicating data on disk causes fragmentation that increases seeks for subsequent sequential reads of the same data, thus, increasing latency. In addition, deduplicating data requires extra disk IOs to access on-disk deduplication metadata. In this paper, we propose an inline deduplication solution, iDedup, for primary workloads, while minimizing extra IOs and seeks. Our algorithm is based on two key insights from realworld workloads: i) spatial locality exists in duplicated primary data; and ii) temporal locality exists in the access patterns of duplicated data. Using the first insight, we selectively deduplicate only sequences of disk blocks. This reduces fragmentation and amortizes the seeks caused by deduplication. The second insight allows us to replace the expensive, on-disk, deduplication metadata with a smaller, in-memory cache. These techniques enable us to tradeoff capacity savings for performance, as demonstrated in our evaluation with real-world workloads. Our evaluation shows that iDedup achieves 60-70% of the maximum deduplication with less than a 5% CPU overhead and a 2-4% latency impact.

**2) Read Performance Optimization for Deduplication-based Storage Systems in the Cloud**

**Authors:** B. Mao, H. Jiang, S. Wu, Y. Fu, and L. Tian

Data deduplication has been demonstrated to be an effective technique in reducing the total data transferred over the network and the storage space in cloud backup, archiving, and primary storage systems, such as VM (virtual machine) platforms. However, the performance of restore operations from a deduplicated backup can be significantly lower than that without deduplication. The main reason lies in the fact that a file or block is split into multiple small data chunks that are often located in different disks after deduplication, which can cause a subsequent read operation to invoke many disk IOs involving multiple disks and thus degrade the read performance significantly. While this problem has been by and large ignored in the literature thus far, we argue that the time is ripe for us to pay significant attention to it in light of the emerging cloud storage applications and the increasing popularity of the VM platform in the cloud. This is because, in a cloud storage or VM environment, a simple read request on the client side may translate into a restore operation if the data to be read or a VM suspended by the user was previously deduplicated when written to the cloud or the VM storage server, a likely scenario considering the network bandwidth and storage capacity concerns in such an environment.

To address this problem, in this article, we propose SAR, an SSD (solid-state drive)-Assisted Read scheme, that effectively exploits the high random-read performance properties of SSDs and the unique data-sharing characteristic of deduplication-based storage systems by storing in SSDs the unique data chunks with high reference count, small size, and nonsequential characteristics. In this way, many read requests to HDDs are replaced by read requests to SSDs, thus significantly improving the read performance of the deduplication-based storage systems in the cloud. The extensive trace-driven and VM restore evaluations on the prototype implementation of SAR show that SAR outperforms the traditional deduplication-based and flash-based cache schemes significantly, in terms of the average response times

**3) A Study on Data Deduplication in HPC Storage Systems**

**Authors:** D. Meister, J. Kaiser, A. Brinkmann, T. Cortes, M. Kuhn, and J. Kunkel

Deduplication is a storage saving technique that is highly successful in enterprise backup environments. On a file system, a single data block might be stored multiple times across different files, for example, multiple versions of a file might exist that are mostly identical.With deduplication, this data replication is localized and redundancy is removed – by storing data just once, all files that use identical regions refer to the same unique data. The most common approach splits file data into chunks and calculates a cryptographic fingerprint for each chunk. By checking if the fingerprint has already been stored, a chunk is classified as redundant or unique. Only unique chunks are stored. This paper presents the first study on the potential of data deduplication in HPC centers, which belong to the most demanding storage producers. We have quantitatively assessed this potential for capacity reduction for 4 data centers (BSC, DKRZ, RENCI, RWTH). In contrast to previous deduplication studies focusing mostly on backup data, we have analyzed over one PB (1212 TB) of online file system data. The evaluation shows that typically 20% to 30% of this online data can be removed by applying data deduplication techniques, peaking up to 70% for some data sets. This reduction can only be achieved by a subfile deduplication approach, while approaches based on whole-file comparisons only lead to small capacity savings.

**4) SAR: SSD Assisted Restore Optimization for Deduplication-based Storage Systems in the Cloud**

**Authors:** B. Mao, H. Jiang, S. Wu, Y. Fu, and L. Tian

The explosive growth of digital content results in enormous strains on the storage systems in the cloud environment. The data deduplication technology has been demonstrated to be very effective in shortening the backup window and saving the network bandwidth and storage space in cloud backup, archiving and primary storage systems such as VM platforms. However, the delay and power consumption of the restore operations from a deduplicated storage can be significantly higher than those without deduplication. The main reason lies in the fact that a file or block is split into multiple small data chunks that are often located in non-sequential locations on HDDs after deduplication, which can cause a subsequent read operation to invoke many HDD I/O requests involving multiple disk seeks. To address this problem, in this paper we propose SAR, an SSD Assisted Restore scheme, that effectively exploits the high random-read performance and low power-consumption properties of SSDs and the unique data sharing characteristic of deduplication-based storage system by storing in SSDs the unique data chunks with high reference count, small size and non-sequential characteristics. In this way, many critical random-read requests to HDDs are replaced by read requests to SSDs, thus significantly improving the system performance and energy efficiency. The extensive trace-driven and VM restore evaluations on the prototype implementation of SAR show that SAR outperforms the traditional deduplication-based schemes significantly, in terms of both restore performance and energy efficiency.

**5) Read Performance Optimization for Deduplication-based Storage Systems in the Cloud**

**AUTHORS:** B. Mao, H. Jiang, S. Wu, Y. Fu, and L. Tian

Data deduplication has been demonstrated to be an effective technique in reducing the total data transferred over the network and the storage space in cloud backup, archiving, and primary storage systems, such as VM (virtual machine) platforms. However, the performance of restore operations from a deduplicated backup can be significantly lower than that without deduplication. The main reason lies in the fact that a file or block is split into multiple small data chunks that are often located in different disks after deduplication, which can cause a subsequent read operation to invoke many disk IOs involving multiple disks and thus degrade the read performance significantly. While this problem has been by and large ignored in the literature thus far, we argue that the time is ripe for us to pay significant attention to it in light of the emerging cloud storage applications and the increasing popularity of the VM platform in the cloud. This is because, in a cloud storage or VM environment, a simple read request on the client side may translate into a restore operation if the data to be read or a VM suspended by the user was previously deduplicated when written to the cloud or the VM storage server, a likely scenario considering the network bandwidth and storage capacity concerns in such an environment.

To address this problem, in this article, we propose SAR, an SSD (solid-state drive)-Assisted Read scheme, that effectively exploits the high random-read performance properties of SSDs and the unique data-sharing characteristic of deduplication-based storage systems by storing in SSDs the unique data chunks with high reference count, small size, and nonsequential characteristics. In this way, many read requests to HDDs are replaced by read requests to SSDs, thus significantly improving the read performance of the deduplication-based storage systems in the cloud. The extensive trace-driven and VM restore evaluations on the prototype implementation of SAR show that SAR outperforms the traditional deduplication-based and flash-based cache schemes significantly, in terms of the average response times.