SSD-Assisted Scalable Elasticity Deduplication Storage Systems with Adaptive Sampling
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Abstract
Existing deduplication systems do not adequately take advantage of elasticity. We develop a multi-tier storage architecture with RAM, SSD and HDD to improve the caching capacity of current deduplication systems. We then propose a new deduplication system EAD (Elasticity Aware Deduplication), which has the ability to dynamically adjust the sampling rate and scale the memory and SSD resources to improve overall deduplication performance.

Background
Fig 1. Cloud-based deduplication system

Fig 2. Intuitive test on amount of duplicate detected on two equal-sized(4.7GB) VMs by using equal-size indexes

Design

if currDedupRatio < estmDedupRatio -> downsampling

TABLE 1: Four cases
![Table Image]

<table>
<thead>
<tr>
<th>Case</th>
<th>Fully Sampled, Equal Duplication</th>
<th>Partially Sampled, Equal Duplication</th>
<th>Partially Sampled, Non-Equal Duplication</th>
<th>Fully Sampled, Non-Equal Duplication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size 1</td>
<td>Approximate</td>
<td>Approximate</td>
<td>Approximate</td>
<td>Approximate</td>
</tr>
<tr>
<td>Size 2</td>
<td>Approximate</td>
<td>Approximate</td>
<td>Approximate</td>
<td>Approximate</td>
</tr>
</tbody>
</table>

if downsampling does not help -> Scale up RAM
1. Hot IndexTable stored in RAM
2. RAM is not big enough, then downsampling
3. If triggers migration, then increase RAM by

\[
M_{new} = \begin{cases} 
M_0 + \Delta d, & d < 2 \\
M_{new} \cdot \Delta \cdot (1 - \frac{\sum d}{2}), & d \geq 2 
\end{cases}
\]

4. SSD and HDD as a Fusion drive design

Experimental Results

(1) Deduplication Ratio And Index Usage

The sampling rate is 1 for all of them at the start of back up. The index migration in EAD is triggered when the normalized deduplication ratio drops below 95% (F=0.95), after that, sampling rate doubles(A=2).

(2) Deduplication Efficiency

Neither deduplication ratio nor memory cost alone can fully represent the system performance. We define:

\[
\text{Dedup Efficiency} = \frac{\text{Duplicate Data Detected}}{\text{Index Entry Slots}}
\]

(3) SSD-based Fusion Disk Evaluation

(4) Scaling Up Evaluation

Conclusions

Results indicate that EAD is able to detect more than 98% of all duplicate data, while only consuming less than 5% of expected memory space. Meanwhile, it demonstrates four times greater deduplication efficiency than the state-of-art sampling technique while using less than half of the amount of memory. We further proposed an online scaling up algorithm that takes advantage of the elasticity of cloud computing to dynamically trigger scaling up operations. Our algorithm also offers a complete guideline for its large scale deployment. Moreover, our design saves at least 74% of overall I/O access cost compared to the tradition design.

References

Zhengyu Yang, Yufeng Wang, Chiu C Tan, and Ningfang Mi "Using SSD-Assisted Scalable Elasticity to Improve Online Data Deduplication Storage Systems", 2016, Under Review.