A Micro-Service based Approach for Constructing Distributed Storage System

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Abstract

This paper presents an approach for constructing distributed storage system based on micro-service architecture. By building storage functionalities using micro services, we can provide new capabilities to a distributed storage system in a flexible way. We take erasure coding and compression as two case studies to show how to build a micro-service based distributed storage system. We also show that by building erasure coding and compression as micro-services, the distributed storage system still achieves reasonable performance compared to the monolithic one.

Keywords: distributed storage system, micro service

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1 Introduction

As data volume increases, interactive and data-intensive network services increase. Network services usually rely on large-scale distributed storage systems to achieve data access. In order to ensure user experience, especially the performance requirements of tail latency, a single IO request needs to distribute requests across thousands of servers so that it will generate too much load and should not be affected by other work.

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In addition to the main IO storage function, the distributed system will also provide a variety of storage-related functions for users to use. For example, Ceph[2], a widely used distributed storage system, provides users with compression and erasure coding functions in the RBD client and OSD server[4] modules respectively[3]. However, as the storage-related functions gradually increase, the monolithic architecture, the construction mechanism of these functions, brings negative problems to the main storage system. At the deployment level, multiple functions and IO storage are all executed in the same container, so that the peak load of the node will reach an extremely high level. At the program level, multiple functions and IO requests are carried out simultaneously in the same single program, which is bound to bring unexpected effects among various modules.

Our goal is to provide a better functional construction architecture for developers to develop distributed storage systems. In this case, we present a function construction mechanism from the perspective of code and function called microservice functional modules, based on the concept of microservices. Developer splits each module function into an independent service constructed by the microservice function module mechanism, and encapsulates the related code into a microservice module, which can be independently deployed and run on a different node to make itself compatible with IO application.

We apply the microservice architecture which serves from the front end of the network to the storage backend[1], bringing the unique advantages of microservice to the developers. In this paper, we focus on Ceph[2], and reconstructed its functional modules (compression, erasure) with microservice functional module construction mechanism. While maintaining its module relationship and functions, the storage engine execution model of its system functions is changed to reduce the pressure of single server and optimize the Ceph code structure to reduce the coupling between modules.

2 System Design

The microservice function module construction mechanism is designed to reconstruct the function by splitting it into an independent service, and encapsulate the relevant code
into a microservice module, which can be independently deployed and run on a different node, so that it is separated from IO application and other modules. When IO application uses this function, it needs to call the microservice module through network communication instead of directly calling the exact code.

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Figure 1,2 shows the process when user calls the exact functions with microservice function module construction mechanism. As it calls to start a related operation functions, a client panel, called Instance will be created to pack the function type and parameters into a request and save it into the queue of the Client. The Client then parses and encapsulates the compression request into a network message package and sends it to the Server through the Client’s messenger. As the Server receives the message it will unpack the packet and forward it to the corresponding function class for related operations. After the operation is done, the Server will encapsulate the data into a packet, and send back to the Client. The Client then decapsulate the message and finally forward it back to user through the Instance.

Table 1. Test Configuration

| Device model | Huawei2285 |
|--------------|------------|
| CPU          | (Intel(R) Xeon(R) CPU E5645@2.40GHz)*2 |
| Memory       | 64GB       |
| Network      | async+posix |

Figure 2. The structure and overall process of EC microservices

3 Evaluation

In this section, we implement two case studies on Ceph, one is compression, the other is erasure coding. We use two Huawei 2285 servers to build the original Ceph-12.2.5[2] system and the Ceph system using erasure correction and compression microservices. The environment configuration is shown in Table 1. For erasure coding, we use Ceph’s own IO performance evaluation tool, rados bench, to evaluate the IO bandwidth and latency of erasure objects in the original Ceph system and the system using erasure microservices. For compression, we use Fio to evaluate the performance of system. Figure 3 shows how to merge the compression function into IO application. We insert it into the client rbd. When the client receives IO request, it will compress the data and send it to the OSD server[4] to store data. We use it to evaluate the IOPS, IO bandwidth and latency of compression in the original Ceph system and the system using compression microservices module. We evaluate the performance under different load and different chunk size(4KB, 64KB) of data.

Table 2 shows the performance of compression microservice (Instance) and original compression function (compressor) in Ceph IO randwrite mode with 4KB chunk size under different load. We find that under low load, IOPS and latency of microservices is slightly lower than the original function, while its is even higher than the original compression under
Table 2. Randwrite 4KB IOPS

| Iodepth | Instance | compressor |
|---------|----------|------------|
| 1       | 1000     | 657        |
| 2       | 1680     | 1845       |
| 4       | 2538     | 2836       |
| 8       | 2827     | 2967       |
| 16      | 2006     | 2709       |
| 32      | 2601     | 2587       |
| 64      | 2512     | 2443       |
| 128     | 2457     | 2300       |

high load. This shows that with small granularity, the performance of compressed microservices is close to that of the original version, and compression time is the main factor affecting performance, instead of network transmission time.

Table 3 shows the performance of compression microservice (Instance) and original compression function (compressor) in Ceph IO write mode with 64KB chunk size under different load. We find that under low load, the bandwidth of the microservice is much lower than the original compression function, which is about 1/2 of its bandwidth, while under high load, as the queue depth increases, the bandwidth gap between them gradually decreases. When the load reaches 64 queue depth, the bandwidth of the microservice reaches its peak, which is about 0.75 of original. This shows that under large granularity and high load, network transmission time is the main factor affecting performance. For reducing the pressure on a single server, optimizing the Ceph code structure, and decreasing the coupling between modules, the performance degradation is acceptable.

4 Conclusion

In this paper, we present a function construction mechanism from the perspective of code and function called microservice functional modules, based on the concept of microservices. We apply it to the storage backend, bringing the unique advantages of microservice to the developers. This mechanism reconstruct the function, and split it into an independent service, and encapsulate the relevant code into a microservice module, which can be independently deployed and run on a different node, so that it is separated from IO application and other modules. We focus on Ceph, and reconstructed its functional modules (compression, erasure) with microservice functional module construction mechanism. While maintaining its module relationship and functions, the storage engine execution model of its system functions is changed to reduce the pressure of single server and optimize the Ceph code structure to reduce the coupling between modules.

References

[1] James Lewis and Martin Fowler. [n.d.]. Microservices. https://martinfowler.com/articles/microservices.html. Accessed 2014.
[2] Sage A. Weil. [n.d.]. Ceph. https://github.com/ceph/ceph/. Accessed 2006.
[3] Sage A. Weil, Scott A. Brandt, Ethan L. Miller, Darrell D. E. Long, and Carlos Maltzahn. 2006. Ceph: A Scalable, High-Performance Distributed File System. In 7th USENIX Symposium on Operating Systems Design and Implementation (OSDI 06). USENIX Association, Seattle, WA. https://www.usenix.org/conference/osdi-06/ceph-scalable-high-performance-distributed-file-system
[4] Sage A. Weil, Andrew W. Leung, Scott A. Brandt, and Carlos Maltzahn. 2007. RADOS: A Scalable, Reliable Storage Service for Petabyte-Scale Storage Clusters. In Proceedings of the 2nd International Workshop on Petascale Data Storage: Held in Conjunction with Supercomputing ’07 (Reno, Nevada) (IPDPS ’07). Association for Computing Machinery, New York, NY, USA, 35–44. https://doi.org/10.1145/1374596.1374606