PathFS: A Streaming File System for Edge Environments

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Motivation

As computers ubiquitously spread out globally, the current state-of-the-art cloud computing applications will hardly meet the demands in the near future. With the emergence of the internet of things (IoT), hundreds of smart devices will be connected in a small area, and merely putting the cloud servers in charge of the entire computation tasks will consume tremendous bandwidth and incur unacceptable latency. Edge computing presents a unique solution that exploits the computing power of each node and saves bandwidth considerably. That is, breaking down the computation tasks and executing them on various end-user devices (called edge devices), network cells or routers (called cloudlets), and the cloud servers. One motivating usage of edge computing is various always-on sensors and cameras that operate within a company, facility, or city. Human operators may want to access the live data collected by the sensors, and more powerful cloud servers may be running analytical algorithms on them. Therefore, a streaming file system tailored for edge computing environments can provide accessibility, scalability, low latency, and low bandwidth consumption. To achieve that goal, we build our desired system on top of PathStore [1], an edge computing storage system that offers a light-weight hierarchical key-value storage. We use PathStore as the baseline and tailor it to meet the mentioned demands of a streaming file system. The modifications involve changing PathStore's update propagation policy to achieve the desired latency for real-time streaming.

Prior Work

Several works have been done on file systems and streaming. For example, IPFS [2] and Ceph [3] are widely used distributed file systems that offer peer-to-peer replication. Moreover, Anna [4] provides a highly scalable key-value store that relies on causal consistency. In terms of streaming file systems, TokuFS [5] is a non-distributed file system that is tailored for streaming. Other work addresses the problem of HD streaming in distributed environments as well [6]. Despite the various works, they mainly address ordinary distributed systems, not edge environments where different nodes have entirely different capacities. This unique characteristic of edge environments deserves independent attention to create systems that exploit its benefits.

Timeline

PathStore offers a sound infrastructure for deploying edge applications. It is built based on Apache Cassandra; hence many Cassandra applications can be run on PathStore will little changes on the codebase. The baseline implementation of our project will be a mere client-side schema that is run on PathStore. Second, we need to modify PathStore to be more suitable for the real-time streaming of files. The current implementation involves periodic upwards and downwards updates for replicating the data from the reader to the writer. However, we need to implement an event-driven approach that instantly transfers the new pieces to the reader. The baseline and the event-driven approach are expected to be done by the first milestone (March 3rd). Afterward, in order to reduce latency even further, we can implement a multi-parent approach where data is transferred through shorter paths than the existing hierarchical paths. This method is expected to be implemented by the second milestone (April 7th). Fault tolerance and implementation nuances should also be taken into account by that date.

References

[1] S. H. Mortazavi *et al*, "Pathstore, a data storage layer for the edge," in *Proceedings of the 16th Annual International Conference on Mobile Systems, Applications, and Services,* 2018, .

[2] J. Benet, "Ipfs-content addressed, versioned, p2p file system," *arXiv Preprint arXiv:1407.3561,* 2014.

[3] S. A. Weil, "Ceph: reliable, scalable, and high-performance distributed storage," 2007.

[4] C. Wu *et al*, "Anna: A kvs for any scale," *IEEE Trans. Knowled. Data Eng.,* 2019.

[5] J. Esmet *et al*, "The TokuFS streaming file system." in *HotStorage,* 2012, .

[6] H. Duan *et al*, "A high-performance distributed file system for large-scale concurrent HD video streams," *Concurrency and Computation: Practice and Experience,* vol. 27, *(13),* pp. 3510-3522, 2015.