Key Techniques and Supporting Tools of Consistency Checking in Distributed System \*

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ABSTRACT

Nowadays more and more Internet-scale systems replicate data in distributed data centers for better performance. However, replicas bring us both convenience and the issue of conflict resolution. In most scenarios, distributed system designers have to sacrifice consistency for availability and partition tolerance. Therefore, some consistency models have been proposed for tradeoffs between consistency and performance. In our research, we investigate the problem of checking whether a given execution trace of a distributed data-store system adheres to a certain consistency model. And we design a scalable platform which can give the traces produced by different distributed systems a efficient check upon different consistency models. Moreover, we devise some techniques for the optimization of checking and a suite of supporting tools.

KEYWORDS

consistency, testing, distributed system

1 Introduction

Today more and more Internet-scale systems replicate data in distributed data centers for large throughputs, low latency and high fault-tolerance. Just as there is no free lunch in the world, replicas bring us both the improvement of performance and the issue of conflict resolution which is a rather thorny problem.

In 2000, Eric Brewer introduced the idea that there is a fundamental trade-off between consistency, availability and partition tolerance, which has become known as the *CAP Theorem* [1]. Since it is impossible to achieve both consistency and availability in an unreliable system, it is necessary to sacrifice one of these desired properties [2]. Partition tolerance is indispensable in the practical scene because the system must continues to operate despite an arbitrary number of messages being dropped or delayed by the network between nodes. Also we cannot sacrifice availability considering the user experience, which every request receives a non-error response in a certain time in spite of no guarantee that it contains the most recent write. Hence, programmers have no choice but to use weak consistency to provide specifications instead of strong consistency.

However, there is a huge gap between totally weak and just a bit weaker that strong consistency. So many consistency models such as quiescent consistency, basic eventual consistency, causal consistency, sequential consistency, have been proposed to help specify and verify distributed systems especially distributed data storage. Different consistency models have different guarantees, different performance and different difficulty of implement. Given the potentially-huge amount of system that relies on these distributed data storage systems, it is important to maintain precise specifications and ensure that implementations adhere to their consistency specifications.

Testing a distributed data storage system raises two issues. First, it is hard to derive a suitable set of testing scenarios, e.g., faults to inject into the system and the set of workloads to be executed. Second, it is hard to check the given execution satisfies the consistency model efficiently. The Jepson framework have been design to solve the first issue by using randomization. However, the second issue is ignored in some sense.There are some consistency models which specify the weak-consistent distributed data storage, but we find few validation tools can check real executions upon various consistency models due to the complexity of checking correctness.

In this work, we aim to develop a platform that checks the executions from different systems upon different consistency specification under the visibility-arbitration framework in order to get a precise specification of a system [3]. And we use pruning technique to reduce the searching space of checking, which makes it possible to check large-scale execution traces in an acceptable time. With these tools, we can obtain the relatively precise consistency specification of the system and find the subtle consistency difference between implementations of the same algorithm thus we can measure the consistency of distributed data storage systems.

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